Issued March 16, 1914.

HAWAII AGRICULTURAL EXPERIMENT STATION,
E. V. WILCOX, Special Agent in Charge.

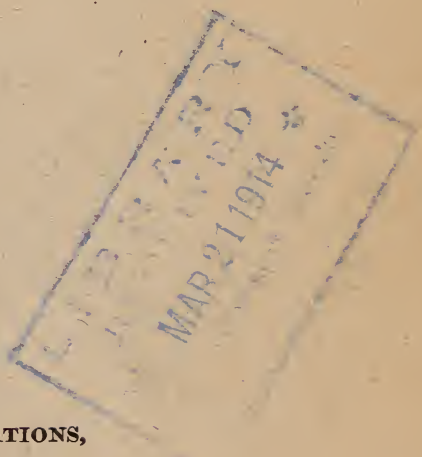
ANNUAL REPORT

OF THE

HAWAII AGRICULTURAL EXPERIMENT STATION

FOR

1913.



UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

E. V. WILCOX, *Special Agent in Charge*
J. EDGAR HIGGINS, *Horticulturist.*
W. P. KELLEY, *Chemist.*
C. K. MCCLELLAND, *Agronomist.*
D. T. FULLAWAY, *Entomologist.*
W. T. MCGEORGE, *Assistant Chemist.*
ALICE R. THOMPSON, *Assistant Chemist.*
C. J. HUNN, *Assistant Horticulturist.*
V. S. HOLT, *Assistant in Horticulture.*
C. A. SAHR, *Assistant in Agronomy.*
F. A. CLOWES, *Superintendent Hawaii Substations.*
W. A. ANDERSON, *Superintendent Rubber Substation.*
J. DE C. JERVES, *Superintendent Homestead Substation.*
J. K. CLARK, *Superintendent Waipio Substation.*
G. COPP, *Superintendent Kula Substation.*

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LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, July 25, 1913.

SIR: I have the honor to transmit herewith and to recommend for publication the annual report of the Hawaii Agricultural Experiment Station for the fiscal year ended June 30, 1913.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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By E. V. Wilcox, *Special Agent in Charge.*

DEMONSTRATION FARMS.

The continued support furnished to this station by the appropriation of funds by the Territorial Legislature has made possible the prosecution of various practical demonstrations and experiments at six substations located at Glenwood, Hilo, Hana, Waipio, Homestead, and Waiakoa. At the recent session of the Territorial Legislature the yearly appropriation was increased from $10,000 to $15,000 for the purpose of carrying on the work at these demonstration farms and others to be established, as well as assisting in a cooperative scheme of marketing island products. The additional substations for which plans have already been made are to be located at Kaupo, Kapaa, Laupahoehoe, Waimea, and in Kona.

With the exception of the substations at Glenwood and Hilo, the basis of operations on the substations or demonstration farms is of a cooperative nature. The funds supplied for the purpose of carrying on substation work are quite inadequate to put up buildings, buy horses, mules, machinery, and other equipment, and hire labor for such work as would be necessary on the areas in question. As already indicated, the only substations on which this method of procedure has been adopted are the Glenwood and Hilo substations, particularly Glenwood, where especially discouraging conditions of agriculture existed and where large areas of valuable land were available for homesteading. On all the other substations the plan has been essentially to offer a small subsidy to the man who was considered best fitted to carry on the work in each community.

The choice of the superintendent of the substation has in all cases been reached in conference with the various members of each community. A plan for certain practical experiments and demonstrations is then prepared by the station and this plan is carried out on the homestead owned by the superintendent. No experiments involving unnecessary expense to the superintendent are undertaken, and all produce raised on the homestead belongs to him. The subsidy

which has been offered to encourage the work has been in each case merely sufficient to compensate the superintendent for the extra time involved in keeping records of the yields, cost of production, and on other points on which it is necessary to have definite information. The practical benefits from this method of carrying on demonstration work have been even greater than was to be expected, without considering the extreme economy of this method of procedure.

Taking as an illustration the community at Homestead, Kauai, where at the time of the establishment of the substation a large Portuguese community was struggling under debt and under a discouraging uncertainty as to what could be profitably planted, or what cultural methods to adopt for such crops as they might wish to try, it is easy to obtain convincing proof of the value and economy of the substation work by making a visit to this community at the present time. The results obtained by the superintendent of the substation under the direction of this station have led to the adoption of improved methods throughout the whole community, which in turn have resulted in little less than a revolution in the farming methods of the community. By adopting the methods recommended by the station the superintendent of the Homestead substation produced this year a yield of 24 tons of pineapples per acre, which is far in excess of the average yield of this fruit. In addition to pineapples, methods have been adopted for the profitable production of corn, potatoes, sweet potatoes, cabbage, and a number of other vegetables. These results have been obtained by the expenditure of $300 annually on the part of the station. The members of the Portuguese community in question three years ago were all deeply in debt, while at present a considerable proportion are entirely out of debt and the remainder probably will be within the next two or three years. Not only have the financial benefits to the community as a whole been quite out of proportion to the small sum expended for demonstration work, but the spirit of the community has become correspondingly more optimistic and a far greater intellectual interest is now taken in the business of farming.

A further advantage of this method of carrying on demonstration work under Hawaiian conditions lies in the fact that the produce of the demonstration farm belongs to the homesteader and not to the station. There is almost always a feeling of resentment at what small producers consider the injustice of a Government institution producing farm crops which must be sold in competition with their own produce. This annoying cause of friction is avoided by the method just outlined, and the results of improved methods which are so obvious on the demonstration farm are clearly understood by all members of the community to be obtained not by a Government institution with the finances of the Government back of it, but by an ordinary farmer

using economical methods which can be adopted by every member of the community.

At the Glenwood substation the work of the year was continued along the same lines as have been previously described. Attention was chiefly devoted to putting the dairy industry of that section of Hawaii on a profitable basis. At the substation a small modern creamery plant was established and the milk supplied by a few dairymen who were interested in the experiment was received, skimmed, and the butter churned. This work was undertaken with the distinct understanding that as soon as a sufficient number of dairymen were convinced of the desirability of forming a cooperative creamery they should form such an association and take over the business of making the butter of the community. Starting with an output of 500 pounds of butter per month, the creamery soon worked up to the production of 2,000 pounds monthly, at which time the Glenwood Creamery Co. was organized on a strictly cooperative basis, for the purpose of making and handling the butter of all the dairymen in that section of Hawaii. The work of the Glenwood substation from now on will be largely along the lines of improving the dairy stock of the neighborhood, learning and demonstrating better methods of forage production, developing improved cultural methods for garden vegetables and flowers, and assisting in any other agricultural industry which gives promise of profit to the homesteaders of Glenwood.

At the Hilo substation attention has been given to various points in the cultivation of bananas and taro. While these experiments have not yet been brought to a final conclusion, it is apparent that the results will be sufficiently interesting to warrant a separate publication in the near future.

At the rubber substation experiments have been carried on with a great variety of tapping methods for Ceara rubber. Some of these methods have recently been outlined [1] and need not be repeated in this connection. It is sufficient to say that a method for tapping Ceara rubber has been devised by which rubber can be obtained for a smaller cost of production than has heretofore been found possible with this kind of rubber. Arsenite of soda has been generally used again this year over the whole area devoted to rubber and appears to be the only efficient method of destroying weeds in this section. No injurious effects have been observed from its use. The only additional treatment that seems necessary in preserving satisfactory soil conditions is dynamiting. Preliminary experiments indicate that by dynamiting the soil between rubber trees and spraying with arsenite of soda excellent drainage conditions can be maintained and the weeds can be held strictly in check. The fertilizer experiments which have thus far been carried on with rubber, while indicating certain con-

[1] Hawaii Sta. Press Bul. 44.

clusions regarding the proper fertilizer to use for Ceara rubber, are thought to rest on the use of too small an area of ground to give results of reliable certainty. Plans have already been made, therefore, to carry on a fertilizer test on 4 acres of uniform trees for the coming season of tapping. From this experiment it is likely that definite conclusions can be drawn as to the influence of various fertilizers upon the flow of latex and the growth of the trees. In addition to work with rubber, a number of experiments have been carried on with intercrops between the rubber trees. Corn, sweet potatoes, broom corn, and roselle have yielded profitable returns, and all such cultivation between rubber trees has the added advantage of keeping the soil in better tilth and thereby hastening the growth of the trees.

The excessive drought which prevailed at the Waipio substation during the past year was the cause of a very unsatisfactory growth in nearly all the crops with which experiments were made. While the conditions of the past year were unusually unfavorable it was thought best to devote a larger portion of the substation to pineapples, particularly since with the extension of the pineapple industry better facilities are offered for disposing of this crop than for most crops in the Waipio neighborhood.

At the Waiakoa substation a start has been made toward determining whether it is possible to control the potato blight, which has ruined the potato crop of this section nearly every year for the past 30 years or more. Here, as at Waipio, the excessive drought rendered the experiments of the first season somewhat doubtful, and the experiments will have to be repeated under more favorable conditions. It is apparent, however, that whether or not an economical method can be developed for controlling the blight of potatoes, great improvement can be brought about in the method of corn cultivation which prevails over the several thousand acres of this district.

COOPERATIVE MARKETING.

The Territorial Legislature, at its last session, specified that the funds allotted to this station to assist in its work should be devoted to the further development of demonstration farms in various parts of the Territory and to the devising of better means for marketing farm produce. In order that this may be accomplished more satisfactorily it seems necessary to devise a general scheme of cooperative organizations for farmers in various parts of the Territory, with the idea of ultimately bringing about an affiliation between all of the cooperative associations, with a central office in Honolulu to promote the proper marketing and distribution of farm products. With this end

in view a beginning has been made, with the result that six cooperative associations of farmers have already been formed. This list includes the Glenwood Creamery Co., the Hawaii Poultry Association, the Homestead Farmers' Association, Kapaa Farmers' Association, Haiku Farmers' Association, and Waimea Farmers' Association. Pursuant to joint resolution No. 1 of the 1909 session of the Legislature of Hawaii, the special agent of this station was appointed chairman of the Fruit Growing and Truck Farming Commission, to draw up plans for the improvement of marketing conditions among the farmers of Hawaii. The report on this subject was published in 1910, the principal features of which have served for further work along the same line. At present there seems to be no method by which the farmers can economically market their crops in the Territory except by the formation of cooperative associations. In no other way can a uniform supply of produce be furnished to any particular market. Without a uniform and constant supply it is impossible to build up and hold a trade. Unless a supply of any given product is shipped regularly to the Honolulu market the dealers refuse to handle island produce, and make definite arrangements for regular shipments by boats from San Francisco. The practical results shown in the rapid development of the market for local butter and buttermilk from the Glenwood Creamery Co. show clearly how effectively this plan obviates the great disadvantages under which the farmer must labor if he operates independently. Not only is he unable independently to maintain a uniform supply and hold his trade, but he is under the disadvantage of having to pay a higher freight rate for small shipments than is the case where associations are formed among all members of a community who are occupied in producing the same crop or product. The formation of cooperative associations has already shown great benefits, and has fully justified itself from the social and intellectual side alone, without reference to the business aspect of the matter. The frequent regular meetings of the members of the community bring about a free interchange of ideas as to the kind of crop to be raised, the methods of culture, and all other matters concerned with the production and marketing of crops. The social activities of such gatherings bind the communities together more closely than could be accomplished by other means. It is possible to secure a more complete set of agricultural publications for a community library than could be obtained by any one individual. All the business, social, and intellectual interests of the community, therefore, center naturally about the cooperative association.

It is obviously impossible for the station to actually handle produce for farmers in the manner of commission merchants or dealers. Even

if this were possible it would merely place an additional link in the already too long chain of middlemen between the producer and the consumer. It is a very simple matter, on the other hand, for the station to keep various cooperative associations informed as to the state of the market in Honolulu by means of brief market statements showing what kind of produce is needed, the quantities, the preferred method of packing, and the difficulties and losses incurred from improper methods of packing and shipping. The secretaries of cooperative associations can in turn keep the station informed as to the conditions of the crops in each community, the amount of produce which is nearly ready for market, and in this way the station can act, with very little expense, in addition to its ordinary work, as an effective means of bringing the producer and consumer together. It is believed that within a period of two years the workings of the cooperative association will become familiar to the majority of farmers with benefits so obvious as to bring about a complete affiliation of the different associations, at which time the farmers can maintain at their own expense, and with profit, a market bureau in Honolulu for handling and disposing of their crops.

ENTOMOLOGICAL INVESTIGATIONS.

Advantage was taken of an opportunity offered by a special expedition to Laysan Island to accompany the party and make a study of insect conditions on the island. The entomologist obtained a rather complete collection of the insects of Laysan, some of which proved to be new and have been described, while other biological observations with reference to the peculiar flora and fauna of Laysan were made.

In connection with a series of experiments to determine the possibility of artificial fertilization of queen bees a thorough study was made of the biology of bees in Hawaii. It is still uncertain whether a satisfactory method of artificial fertilization can be put on a practical basis, but a bulletin on the subject of bee keeping in Hawaii has been prepared. Studies were also made of the insect pests of tobacco and vegetables, with special reference to the life history of these insects, their parasites, and artificial methods of control. The entomologist has spent a considerable portion of his time, by cooperative arrangement with the Bureau of Agriculture and Forestry, in breeding and distributing the various parasites recently brought to Hawaii by Dr. F. Silvestri for the control of the Mediterranean fruit fly. The prospects for the successful establishment of some of these parasites are at present quite promising.

HORTICULTURAL INVESTIGATIONS.

The studies which this station has been making on papaya have been continued during the year, and a bulletin has been prepared[1]. One of the most interesting results of this work is the apparent certainty that within one or two more generations of papaya breeding the dicœcious condition in which this tree ordinarily occurs will be eliminated, with great practical advantage to the papaya grower. A strain has already been originated in which over 92 per cent of the trees are self-fertile fruit-bearing trees. This has been accomplished by close fertilization of hermaphroditic flowers, with the result that the occurrence of male trees has already been largely eliminated and the variation due to cross-fertilization thus avoided. It has been found also to be a very easy matter to graft papayas. A union takes place even between the pith of the scion and the stock.

In further work with pineapples it has been found that the shape of the fruit is subject to hereditary transmission as well as other characters. Suckers from plants which bear cylindrical fruits are far more likely to produce cylindrical fruits than are plants which bear conical fruits. Since the cylindrical shape is of considerable importance in canning, for the reason that a larger number of slices of uniform size can be obtained, it is desirable to select suckers with reference to the shape of fruits which they will produce.

There is a constantly increasing demand for hibiscus cuttings for the beautification of army posts and private grounds. The station has done a large amount of hybridizing work with the hibiscus material at hand, and has issued a bulletin on the cultivation of hibiscus, together with a horticultural description of about 235 of the more promising varieties.[2]

CHEMICAL INVESTIGATIONS.

The analytical work necessary in making a general soil survey of Hawaii is practically completed, and a bulletin on this subject is being prepared. Many soils have been found of unusual physical and chemical properties, such as exceedingly high content of titanium, magnesium, humus, lime, and other ingredients, and varying degrees of looseness or compactness of texture. In order to gain an idea of the general processes of change which were taking place in soils in Hawaii, analyses have been made of various samples of lava taken from historical flows of known date. It has thereby been possible to study the formation of Hawaiian soils from the standpoint of their history and to learn the changes which have taken place in the disintegration of lava into agricultural soil. The opportunity for such study is one rarely presented, except in Hawaii.

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[1] Hawaii Sta. Bul. 32. [2] Hawaii Sta. Bul. 28.

In the study of the nitrogen content of Hawaiian soils it has been found that fallow or virgin soils contain no nitrate, or merely a trace, while the amount of ammonia may be rather large. Upon thorough cultivation, however, nitrification takes place quite rapidly, with the result that the form of soil nitrogen is quite different in cultivated and uncultivated soils.

It has long been known that on many soils heat renders the soil constituents much more active, resulting in larger production. This fact is exceedingly conspicuous on nearly all the soils of Hawaii. An elaborate study was made of the effect of various degrees of heat on different soils.[1] In general it was found that all of the essential plant foods and all their mineral elements are rendered much more available and soluble by the application of heat. Certain physical alterations also result from the application of heat, particularly the flocculation of heavy clays. An elaborate series of experiments was made on the fixation of fertilizers in Hawaiian soils. These experiments will soon be brought to a close. It is already apparent that the soils of Hawaii have the power of fixing large quantities of phosphoric acid, potash, and ammonium sulphate, but only minute quantities of nitrate of soda. The bearing of this work upon the practical use of fertilizers is obvious. During the year experiments have been carried on continuously to determine the nature of nitrogen in Hawaiian soils, and the ratio which exists in different soils between lime and magnesia. Both of these matters will soon be brought to a conclusion.

A study of the product of the native rubber tree (*Euphorbia lorifolia*) showed that the latex of this tree, while containing only a low percentage of true rubber, gives a high yield of resin, which has been tested by a number of manufacturers, with a result that it seems to be identical with chicle. An offer of 70 cents a pound has been made for the product, and it is likely that a new industry will soon be established in gathering this product.

Some experiments have been made in an attempt to develop methods of economically utilizing the large quantities of pineapple juice wasted in the canning process. While pineapple juice may perhaps be most economically used by condensing into a sirup to replace a part of the sugar in canning, it may also be used in the production of a good quality of vinegar. By the quick process a vinegar containing from 3½ to 4½ per cent of acetic acid may be produced in 24 hours, and the percentage of acid will increase by subsequent standing. No difficulty is experienced in securing the acetic fermentation after the proper alcoholic fermentation has been brought about, but the main difficulty is encountered in handling the juice so as to prevent an improper fermentation at the start, thus destroying the flavor of the vinegar or preventing the formation of sufficient alcohol.

[1] Hawaii Sta. Bul. 30.

AGRONOMICAL INVESTIGATIONS.

During the year the agronomist devoted his attention chiefly to the present status of forage crops in the Territory and methods of producing larger quantities of feed for stock. The fact that large quantities of Australian beef have been shipped to Honolulu indicates the desirability of producing more beef, of better quality, upon the ranches. The areas of corn are rapidly increasing, particularly in connection with ranch work. Much assistance has been given by the station in extending the growing of corn and encouraging the erection of silos for preserving corn, legumes, cane tops, and various other forage crops. During the year several silos were constructed and others are in process of construction. A general survey is being made of the ranches in order to gain information about the growth of various kinds of native and introduced grasses, with the idea of being in position to help in the further improvement of the grazing areas. For this purpose experiments have been carried on with a large number of legumes, grasses, and other forage crops. Some of these have shown striking value under Hawaiian conditions. Data are gradually being accumulated which will help in determining more closely the seasons in which field corn and sweet corn can be grown profitably.

Difficulties have been almost universally experienced in growing potatoes and cotton. Two root diseases attack the potato, and one of them is of an unusually serious nature. In some localities it is impossible to escape the disease oftener than one year in ten. There seems to be little or no difference in the resistance of different varieties to the disease. Experiments are now under way, however, to determine whether a resistant strain can be developed. Before the existence of this disease in Hawaii no difficulties were experienced in growing potatoes. With the cotton the most serious obstacle is the pink bollworm, which continues to breed in undiminishing numbers. This insect lives also in the pods of other members of the mallow family, particularly in the hibiscus. There seems to be no really practicable artificial remedy for the pink bollworm so long as cotton fields are surrounded by uncultivated fields in which stray plants of cotton and other mallows are growing. Some importations of parasites of the pink bollworm have been made from India, without success. It is hoped during the coming year that a more effective parasite may be obtained from Africa. The station has distributed cuttings and tubers of the ordinary mainland sweet potato throughout the Territory. This variety is far superior in flavor to the varieties commonly grown in Hawaii, and in moderately dry and loose soil yields heavily. The crop of tubers, however, is unsatisfactory on heavy clay soils, particularly where the rainfall is heavy.

MISCELLANEOUS.

The experiments conducted by the station on kukui oil have attracted the attention of oil chemists and oil dealers in various parts of the world. Urgent inquiries have been received from 30 or more large oil dealers as to where the oil can be obtained in commercial quantities, and how much can be depended upon as an annual crop. The requests received indicate that 100,000 barrels of kukui oil annually would readily find sale at a price somewhat above linseed oil. Three firms are now preparing for the collection of the nuts and the production of the oil.

The development of the algaroba-meal industry is proceeding at a rapid rate. The rights to pick beans from large areas of Government land and private estates are now sold to the highest bidder for a long term of years. The yield per acre of these beans proves to be much larger than was estimated before reliable statistics on the subject were had. According to the figures as to the harvest for the past year the yield varies from 2 to 10 tons of beans per acre. The product is being used more and more widely, and has been introduced into the ration for Army horses in Hawaii.

For several years there has been a demand for dried roselle beyond what could be furnished from the small patches of this plant heretofore grown in Hawaii. In the experiments of the station it was found that roselle grew very satisfactorily between the young rubber trees and elsewhere. An area of 100 acres was planted this year to roselle for the purpose of obtaining the dried product for use in the manufacture of jams and jellies. One jam manufacturer has found it possible to pay 40 cents a pound for the dried product, and this price yields a reasonable return to the grower.

There are a number of chicken diseases in the Territory, but perhaps the most prevalent is sorehead. This trouble in many instances appears to be associated with the occurrence of eye worm of chickens. Since little was known about the life history of the eye worm a study was made of this problem, during which the greater part of the life history of the eye worm was worked out and the results published in a bulletin dealing with that subject.[1] The method of treatment for eye worm recommended in the bulletin has since been generally used with good results.

As a result of the experiments carried on at the station in dynamiting land, this method of securing drainage has been quite widely tried, with excellent results. It has been found possible to bring about fine drainage in soil on which satisfactory drainage conditions could not otherwise be produced, by exploding sticks of dynamite at depths of 4 feet, at points 20 feet apart both ways throughout the

[1] Hawaii Sta. Press Bul. 43.

field. If the soil is well tamped it does not disturb the surface appreciably. It has, therefore, been found possible to dynamite pineapple fields immediately after the first crop has been taken off, and in this way start the growth for the ratoon crop more rapidly than was otherwise possible, and also to prevent the packing of the soil beneath the level of cultivation as well as surface erosion.

During the year the following publications were issued by the station, totaling 610 pages:

Annual Report for 1912.
Production and Inspection of Milk.
Bulletin 27, Insects Injurious to Corn.
Bulletin 28, Effect of Manganese on Pineapple Plants, and the Ripening of the Pineapple Fruit.
Press Bulletin 37, *Euphorbia lorifolia*, a Possible Source of Rubber and Chicle.
Press Bulletin 38, The Use of Dynamite in Farming.
Press Bulletin 39, The Extraction and Use of Kukui Oil.
Press Bulletin 40, Silos, Silage, and Silage Crops for Hawaii.
Press Bulletin 41, Tin Cans *v.* Pots for Seedling Plants.
Press Bulletin 42, Corn Culture and Improvement.
Press Bulletin 43, Eye Worm of Chickens.
Press Bulletin 44, Plantation Rubber in Hawaii.

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REPORT OF THE ENTOMOLOGIST.

By David T. Fullaway.

The entomologist was present at the station and engaged in various lines of investigation continuously throughout the year save for a brief period in December-January, when he accompanied a scientific expedition to the islands lying northwest of Hawaii to investigate and report upon the insect fauna of these outlying portions of the archipelago. The routine work of the office was attended to as usual and the insect collection and library were enlarged by many accessions of material and books. The inspection of plants under the new horticultural inspection board regulations consumed a great deal of time which might have been more profitably employed.

LAYSAN INSECTS.

As a result of the expedition above mentioned, a fine collection of insects from Laysan Island is at hand, throwing considerable light on the fauna of these low islands, which was previously known only from half a dozen or so specimens brought back by earlier visitors. The collection includes about 60 species, at least 5 of which are new to science and will be described by specialists elsewhere,

The following preliminary list will give an idea of the nature of the fauna:

Euplexoptera.

1. *Anisolabis annulipes.*
2. *A. maritima?*

Orthoptera.

3. *Periplaneta americana.*
4. *Polyzosteria soror.*
5. *Phyllodromia* sp.

Corrodentia.

6. *Ectopsocus fullawayi.*
7. *Kilauella* sp. This and preceding species determined by Enderlein.

Thysanoptera.

8. Thrips.

Hemiptera.

9. *Reduviolus blackburni.* Also collected by Schauinsland.
10. *Oronomiris hawaiiensis.*
11. *Nysius* sp.
12. *Triphleps persequens.*
13. *Kelisia* n. sp.
14. *Aphis* sp.
15. *Saissetia nigra.*
16. *Pseudococcus* sp.

Diptera.

17. *Lucilia* sp.?
18. *Musca domestica.*
19. *Hydrophorus* sp.
20. *Lispe* sp.?
21. *Scatella hawaiiensis sexnotata.*
22. Tachinid. Unidentified.
23. Drosophilid. Unidentified.
24. Agromyzid. Unidentified.
25. Phorid.

COLEOPTERA.

26. *Dermestes cadaverinus.*
27. *Attagenus plebinus.* Collected by W. A. Bryan.
28. *Necrobia rufipes.*
29. *Alphitobius diaperinus.*
30. *Macrancylus linearis=Haloscenus immigrans.* Determined by Perkins.
31. *Oodemas* n. sp.
32. *Rhyncogonus* sp. Collected by W. A. Bryan.
33. *Tribolium ferrugineum.*
34. *Calandra oryzæ.* In stores.
35. *Scymnus vividus.*
36. *S. discidens=S. debilis?*
37. *Stephanoderes* sp.?

LEPIDOPTERA.

38. *Euxoa eremioides.*
39. *E. procellaris=Prodenia* sp. of Perkins.
40. *Agrotis dislocata.*
41. *A. saucia.* Collected by G. P. Wilder.
42. *Nesamiptis laysanensis.* Swezey MS. sp.
43. *Pyrausta dryadopa.*
44. *Hymenia recurvalis.*
45. *Omiodes laysanensis.* Swezey MS. sp.
46. *Crocodosema plebiana.*
47. *Hyposmocoma notabilis.* Only the case recovered.
48. *Trichoptilus oxydactalus?* Collected by G. P. Wilder.
49. Tineid. Unidentified.
50. Tineid. Unidentified.

HYMENOPTERA.

51. *Tetramorium guineense.*
52. *Monomorium gracillimum.*
53. *M. minutum.*
54. *Tapinoma melanocephala.*
55. *Phænopria* sp.
56. *Tropidopria* sp.
57. Wingless encyrtid—Ectromini.
58. *Eupelmus* sp. Collected by G. P. Wilder; determined by Perkins.
59. A mymarid.
60. *Chelonus blackburni.*

BEES.

The earlier part of the year was given to an investigation of the bee industry in connection with some special work on bees—an attempt to fertilize queen bees artificially. While the work has so far given no practical results, it has not been entirely abandoned, and from the entomologist's experience of the methods followed in practical bee keeping a manual of bee keeping for use in the islands has been prepared for publication.

GARDEN INSECTS.

The principal investigation of the year has been of insects injurious to vegetables. On its completion this work will be published in bulletin form. For the present a list is furnished of the injurious forms in connection with the main vegetable crops, with reference to previous work on the subject.

Insects injurious to cabbage, turnip, radish, and other cruciferous crops:[1]

Cabbage butterfly (*Pieris rapæ*) on cabbage.
Imported cabbage webworm (*Hellula undalis*) on cabbage, daikon, and radish.
Diamond-back moth (*Plutella maculipennis*) on cabbage, shirona, turnip, watercress.
Cabbage aphis (*Aphis brassicæ*) on cabbage, daikon.
Peach aphis (*Myzus persicæ*) on cabbage, shirona, daikon, turnip, watercress.
Cabbage-leaf miner (*Agromyza diminuta*) on shirona, daikon, turnip.
Melon fly (*Dacus cucurbitæ*) on cabbage.
Cutworm (*Agrotis ypsilon*) on turnip.
Cutworm (*Agrotis crinigera*) on cabbage, turnip.
Cutworm (*Caradrina exigua*) on cabbage, daikon.
Common plusia (*Plusia chalcites*) on cabbage, daikon, turnip.
Beet webworm (*Hymenia fascialis*) on daikon.
Amorbia (*Amorbia emigratella*) on cabbage, daikon.
Long-horn grasshopper (*Atractomorpha crenaticops*) on cabbage.
Thrips (*Thrips tabaci*) on cabbage.

[1] Chittenden and Marsh. The Imported Cabbage Webworm, U. S. Dept. Agr., Bur. Ent. Bul. 109, pt. 3 (1912).

Of these, the serious pests are the cabbage butterfly, the cabbage webworm, the diamond-back moth, and the aphids. The others are of more or less indifferent nature so far as any actual damage to the crop is concerned. Little can be suggested in the way of remedies, as all the insecticides experimented with by Marsh failed to give appreciable results. In his experience and also in the writer's there is decided advantage in growing under cover until the plants are ready to be set out. The agromyzid fly is very prevalent on all thin-leaved crucifers, but does no great damage. It has some very interesting parasites, which keeps it fairly well checked.

Insects injurious to apiaceous plants—celery, parsley, carrots:
- Cabbage aphis (*Aphis brassicæ*) on celery, carrots.
- Cabbage-leaf miner (*Agromyza diminuta*) on celery, carrots.
- Thrips (*Thrips tabaci*) on celery.
- Common plusia (*Plusia chalcites*) on celery.
- Amorbia (*Amorbia emigratella*) on celery.
- Cotton aphis (*Aphis gossypii*) on celery.
- Mealy bug (*Pseudococcus virgatus*) on carrots.

The only serious pest is the aphis, but it is not very common, and is easily controlled with tobacco sprays.

Insects injurious to potato, tomato, eggplant, and other solanaceous plants:
- Potato tuber moth (*Phthorimæa operculella*) on eggplant, tomato, potato.
- Flea beetle (*Epitrix parvula*) on poha, eggplant, tomato, potato.
- Melon fly (*Dacus cucurbitæ*) on eggplant, tomato, peppers.
- Fruit fly (*Ceratitis capitata*) on peppers.
- Tobacco-pod borer (*Heliothis obsoleta*) on tomato.
- Tobacco hornworm (*Phlegethontius quinquemaculatus*) on tomato.
- Rot fly (*Acritochæta pulvinata*) on peppers.
- Aphis (*Aphis gossypii*) on eggplant, tomato.
- Aphis (*Myzus persicæ*) on peppers.
- Aphis (*Macrosiphum circumflexum*) on poha.
- Cutworm (*Spodoptera exigua*) on tomato, peppers.
- Amorbia (*Amorbia emigratella*) on tomato.
- Plusia (*Plusia chalcites*) on eggplant, tomato.
- Mealy bug (*Pseudococcus nipæ*) on eggplant.
- Mealy bug (*Pseudococcus virgatus*) on eggplant.
- Armored scale (*Saissetia nigra*) on eggplant.

The serious pests are the tuber moth and flea beetle on the stems and leaves and the melon fly on the fruit. For the former, arsenic sprays are recommended. The latter can be kept off by screening or bagging the fruit.

Insects injurious to cucumber, pumpkin, squash, and other cucurbits:[1]
- Melon fly (*Dacus cucurbitæ*) on cucumber.
- Melon stem borer (*Apomecyna pertigera*) on cucumber.
- Beet webworm (*Hymenia fascialis*) on cucumber.
- Cutworm (?) on squash.
- Rot fly (*Acritochæta pulvinata*) on squash.
- Plusia (*Plusia chalcites*) on squash.

The serious pests here are the melon fly and the stem borer and very little can be done in a practical way to prevent their great destructiveness.

Insects injurious to spinach and other amarantaceous plants:[1]
- Beet webworm (*Hymenia fascialis*) on spinach, beets.
- Wireworm (?) on beets.
- Cutworm (*Spodoptera exigua*) on beets.

Insects injurious to onions and other alliaceous plants:
- Thrips (*Thrips tabaci*) on onions, leeks.

[1] Marsh. The Hawaiian Beet Webworm, U. S. Dept. Agr., Bur. Ent. Bul. 109, pt. 1 (1911).

Insects injurious to miscellaneous vegetables:
Cutworm (*Spodoptera mauritia*) on asparagus.
Cutworm (*S. exigua*) on okra, cauliflower.
Cotton aphis (*Aphis gossypii*) on taro and other aroids, okra.
Japanese beetle (*Adoretus tenuimaculatus*) on taro and other aroids, string beans.
Peach aphis (*Myzus persicæ*) on rhubarb.
Amorbia (*Amorbia emigratella*) on okra.
Root maggot (*Phorbia fusciceps*) on garden beans.
Long-horn grasshopper (*Xiphidium varipenne*) on garden beans.

MEDITERRANEAN FRUIT FLY.

The Mediterranean fruit fly has been quite as destructive to practically all soft-pulped fruits this year as last, in spite of a concerted effort to control it by the practice of clean cultivation. Pineapples, grapes, and berries are notable exceptions to the long list of fruits which the fly attacks. Most other fruits are generally infested and the only practical means of protection so far discovered is bagging individual fruits or entire trees.

A beginning has been made in the introduction of natural enemies. On May 16, Dr. F. Silvestri, of the Royal School of Agriculture at Portici, Italy, who had been engaged in the summer of 1912 to search for parasites in West Africa, arrived in Honolulu with numerous examples of seven species of fruit-fly parasites obtained in Africa and Australia. Following out an agreement made several years previous the station has continued to advise the Territorial authorities in regard to this work, and the entomologist has followed with much attention the details of Dr. Silvestri's investigations. Since his arrival the entomologist has given his whole time to the multiplication and distribution of the parasites, and at the present writing there seems to be good ground for believing that at least some of the parasites will become established here and prove effective checks on the fruit fly. An extended report of this work will be made later. At present it can be stated that the two parasites of the pupa of *Ceratitis capitata*, which were brought in large numbers by Dr. Silvestri—one a chalcidid and the other a diapridid—breed readily in the laboratory and can be distributed by the thousands. The larval parasites (species of Opius) were brought in small numbers and are much more difficult to propagate. One or two species as well as other species of pupal parasites show a decided tendency to run to males and thus prevent further multiplication. The work of propagation is being very carefully attended to and will be continued until it is certain that the species have become established or the material fails. As previously stated, with some of the species there is every chance of ultimate success in their establishment under natural conditions.

REPORT OF THE HORTICULTURIST.

By J. Edgar Higgins.

No new projects of importance were started during the year in the work of the horticultural department. Some of the investigations with papayas and with pineapples have reached fruition, and results are apparent in the case of some peach tree pruning experiments. It is also possible to report upon a few minor subjects that have been under experiment.

THE PAPAYA.

Considerable attention has been given to the papaya investigations, which have been under way for several years, and in which results are beginning to be achieved. In an experiment in breeding with hermaphrodite flowers fertilized with their own pollen, it was found that in the first generation of 343 trees, 322 were fruit bearing, or about 93½ per cent. A careful study has been made of all the available literature relating to the papaya, both from the purely scientific point of view and from that of applied knowledge. Through the courtesy of the library of the United States Department of Agriculture, it has been possible to secure the use of several valuable publications which would not otherwise have been available. The library of the Bishop Museum and those of the Hawaiian Sugar Planters' Experiment Station and the College of Hawaii have afforded valuable assistance. This literature has to some degree led into the perplexing problems of sex inheritance. Correspondence with botanists and horticulturists in many parts of the Tropics have brought out valuable data relating to the status of the papaya and other species of Carica in such countries. To all of the scientists and institutions referred to it is desired to express thanks and appreciation. Through the botanic gardens and experiment stations it has been possible to secure seeds of papaya and some other species of Carica from many countries. However, many species from their native habitat in Central America, South America, and Mexico are desired.

The results of the papaya investigations up to June, 1913, have been brought together as a bulletin of this station.[1]

Since the presentation of this bulletin two rather important features have developed which may be mentioned here. One of these is a papaya disease which has just appeared and which is quite new to the station. It appears to be characterized by a wilting of the leaves and a decay of the stem, causing the sudden and entire destruction of the tree. The disease is being studied by Dr. H. L. Lyon and Mr. L. D. Larsen, pathologists of the Hawaiian Sugar Planters' Experiment Station, and every precaution is being taken to prevent its spread.

[1] Hawaii Sta. Bul. 32.

The change in sex of a papaya tree from male to female brought about at times apparently by the cutting back of the top of the tree has been discussed in the bulletin above mentioned, where it was shown that this change takes place only occasionally. Many young male trees of a lot in which the females had matured no fruit were subjected to the removal of the growing portion at the end of the stem. These have not been reported upon. In several instances there appears to be a large increase in the number of hermaphrodite flowers in the inflorescence just below the wound, although many of the trees showed no change whatsoever. None became pistillate trees, and it can not be observed that the new branches bear any more hermaphrodite flowers than the original stem.

A similar experiment was conducted with 15 male trees out of a lot of 16 which were several years old. Seven of these were cut off about 18 inches above the soil, and eight were cut leaving a stem about 4½ feet high. The hollow space within was filled with volcanic ash, covered with plaster of Paris. Four of those cut low and one cut high have sent out no shoots. It is believed from this experience that old trees should not be cut lower than 4 or 5 feet in such tests. None have yet shown any pistillate or hermaphrodite flowers. Some of the branches are without flowers of any kind and may later show new characters.

THE PINEAPPLE.

Two interesting lots of pineapple seedlings are under observation and study. Lot No. 3059 were grown from 131 seeds taken from a single fruit and donated by the Thomas Pineapple Co. (Ltd.). They were collected September 10, 1912, and were the only seeds found in the fruits that passed through the company's cannery during the season's pack, a fact illustrating the rarity of seeds in the varieties grown here. It is not known whether the fruit was the ordinary Smooth Cayenne or of the Queensland variety.[1] The seeds were planted promptly and in two months 72 had germinated in the warm box of the glass house referred to in the report of the assistant horticulturist (p. 27). These seedlings are showing very wide variation. In vigor they range from the very weak to very robust; in color of foliage from dark green to bronze; in habit from upright to procumbent; and from the very spiny to those which it is necessary to examine carefully in order to find any spines.

At about the same time a similar lot of 148 seeds was received from Ginaca Bros., Maunawai, Oahu, which also were taken from a single fruit. These were planted as No. 3060, under the same conditions, 74 of the seeds germinating. They exhibited fully as wide variations as the other lot, as may be seen by reference to the illustration (Pl. I, figs. 1 and 2).

SELECTION OF PLANTS BY FORM OF FRUITS.

It is a matter of great importance to pineapple canners to have fruits of as nearly uniform diameter as possible. Those that are tapering often entail too much waste by reason of the upper slices being too small for first grade in packing. For this reason it seemed

[1] See Hawaii Sta. Press Bul. 36, pp. 21, 22.

desirable to conduct some experiments to determine whether these differences among plants supposedly of the same variety are purely incidental to environmental conditions, or whether they represent characters which may be transmitted through propagation by asexual parts, as suckers, crowns, or slips.

In September, 1910, some plants were selected for preliminary experiment. Those which appeared to the eye to be inclined to the tapering form were selected as such, were measured and divided as follows: Lot 100 (crowns), lot 200 (slips), and lot 300 (suckers). Measurements were taken by placing a carpenter's square over the top of the fruit after the removal of the crown, and taking caliper measurements every inch, beginning 1 inch from the crown. Those fruits appearing to the eye to be barrel shaped or of fairly uniform diameter, were classed as lot 400 (crowns), lot 425 (slips), and lot 450 (suckers). These were all planted at the Thomas Pineapple Co.'s lands at Wahiawa on October 4, 1910. On July 26, 1912, the fruits of the progeny were gathered, except those that had already matured and had been sent to the cannery by mistake by the laborers. The fruits of suckers of lot 450 had all been gathered, and only two fruits remained of lot 300, which also was left out of the calculations on this account. A summary of the measurements is given in the accompanying table.

Tabular summary of measurements of pineapples.

Lot.	Selected as—	Crowns, slips, or suckers.	Difference in diameter, top and bottom slices, 1910.			Difference in diameter, top and bottom slices, 1912.			Average totals.
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	
			Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
100	Tapering.....	Crowns.....	2.125	1	1.534	1.687	0.812	1.102	1.186
200	.....do.....	Slips.....				2.5	.812	1.212	
300	.....do.....	Suckers.....							
400	Square.....	Crowns.....	1.375	.562	.806	1.375	.812	1.02	.932
425	.....do.....	Slips.....				1.187	.437	.787	
450	.....do.....	Suckers.....							

From a study of the above table it would appear that plants bearing pineapples having an average difference in the diameter of their top and bottom slices of 1.534 inches have produced fruits with an average difference of 1.186 inches in diameter. Plants from fruits whose average difference was 0.806 inch have produced fruits with an average difference of 0.932 inch. Such evidence as this experiment affords from a study of the measured fruits points toward a probable transmission of form characters by asexual propagation.

In this connection not only the averages should be studied, but the maximum and minimum variation. It will be seen that the maximum differences in diameter in fruit of parent plants is very close to the maximum in the progeny, both in the "square" and in the "tapering" fruit. The same is true of the minimum diameter variation of parent compared with progeny.

Another means of testing this matter is now being employed. Individual plants of marked character are being selected as they are found. The fruit of each of these is measured separately, and the progeny is being related to the exact plant from which it was taken. None of these has yet come to maturity.

FIG. 1.—PINEAPPLE SEEDLINGS OF NO. 3060.
[Note the wide variation in habit of growth.]

FIG. 2.—PINEAPPLE SEEDLINGS OF NO. 3060, SHOWING SMOOTH AND SPINY PLANTS.

FIG. 1.—GENERAL VIEW OF HIBISCUS GARDEN.

FIG. 2.—LITCHI TREE, FIVE YEARS AFTER PLANTING.

PEACH-TREE PRUNING.

Several years ago some simple experiments were undertaken to determine the best seasons and methods for the pruning of the peach in the tropical climate of the lowlands of this Territory. These have been continued. Without going into the details of the work, it may be stated that the best results have been secured by a severe pruning which is almost the equivalent of a renewal system. This pruning is done in June, very soon after the gathering of the fruit. The tree is almost without foiliage after the pruning, but soon sends out many new branches. It is necessary to go over the trees a little later to remove all suckers that are not required to improve the shape of the tree. The new branches continue to grow vigorously through the summer and fall, suspending their more active growth in the winter and maturing fruit buds.

TOP-WORKING AVOCADOS.

Many of the avocados in the seedling orchard have fruited and such as are not considered worthy of further testing are being top-budded to more valuable varieties. A marked change in method is being tried in this work. Trees 6 or 7 years old have been cut back to stumps about 1½ or 2 feet high, with a sloping cut which has been well covered with heavy paint or wax as a protecting covering. All trees so treated have sent out vigorous shoots which have proved ideal stocks for the reception of buds, being far better in this respect than the side branches of any of the original trees.

CONDITION OF ORCHARDS.

The general condition of the experiment orchards at the present time is excellent. The avocado orchard suffered from insufficient moisture during the prolonged drought of 1912, which probably accounts for a comparatively light crop this year, but the trees have recovered and if sufficient water is available a good crop may be expected in 1914.

The heaviest crop of mangoes that has ever been produced here is now upon the trees, notwithstanding the fact that very many of the fruits were removed on account of the prevalence of the Mediterranean fruit fly. Those remaining are protected with paper coverings. These have not previously been used at the station, and it remains to be seen whether they are to be recommended.

Many of the citrus varieties are fruiting, and budwood from promising kinds has been used in budding nursery stock for distribution.

The orchard of miscellaneous tropical fruits is increasing in interest. The litchi plants imported from China direct, and those received through the Office of Seed and Plant Introduction, are making a very satisfactory growth, and may be regarded as past the critical stage. A tree planted March 14, 1908, is shown in Plate II, figure 2.

The *Feijoa sellowiana* received in March, 1908, from the Southern California Acclimatization Association is fruiting for the first time in Hawaii, having made a satisfactory growth. This is one of the newly introduced fruits, related to the guava, which it resembles in many respects, but is much more delicious, has smaller seeds, and is highly

perfumed. The tree with its silvery-gray foliage is attractive in the landscape, and the flowers, which are a mixture of purple, red, and white, are very beautiful.

HIBISCUS.

Mr. Valentine S. Holt, assistant in horticulture, has devoted much time and painstaking energy during the past few years to work with hibiscus, chiefly along the lines of breeding. The details of this work, which has been done with the close personal cooperation of Dr. Wilcox, have been published as a bulletin of this station.[1] Mr. Holt presents some general features of the work, not touched upon in the special publication, as follows:

There are probably few, if any, plants of more promise for ornamentation than the hibiscus. This plant grows in dry and poor soil, and has been planted in various places at the station where nothing else would prosper. While there may be some people who will think that the hibiscus is of little economic importance, it may be said that its popularity is evidenced by the large demand for new varieties. The first Hawaiian exhibition of hibiscus was held during the month of June, 1911, and this astonished even those most familiar with these plants by the number and beauty of the varieties which were brought together. The second exhibition of hibiscus was held in September, 1912, and this surprised the public even more by the very large number of varieties exhibited, which exceeded the first by several hundred flowers. The hibiscus is now receiving much more public attention, and a great many requests have been received for cuttings of this plant.

Over 125,000 cuttings of the different varieties have been distributed. A method has been adopted in this propagation work by which the plants can be multiplied rapidly. Cutting beds have been prepared in the open by using ordinary beach sand. The cuttings are first tied up in bundles of from 100 to 200 and planted in the sand, where they root in three or four weeks. In this way they are easily handled in planting and transplanting.

Some time has been devoted to the breeding of new varieties of hibiscus. The station has now over 3,000 new seedling varieties under observation, which are the results of last year's cross pollinations. Some of these plants are of great beauty in foliage as well as in flower, which will add much to the floral wealth, not only in Hawaii, but in other parts of the tropics and subtropics. A general view of one of the hibiscus gardens is shown in Plate II, figure 1.

ADVICE AND DEMONSTRATIONS.

The usual calls for information and advice increase from year to year. These have been responded to by correspondence and by verbal advice to inquirers at the laboratory, propagating houses, orchards, and nurseries. In many cases which seemed to justify it, visits have been made by members of the staff.

In closing, it is desired to express appreciation of the faithful and efficient services of Mr. Chester J. Hunn, assistant horticulturist, Mr. Valentine S. Holt, assistant in horticulture, and of those who have done the detail work of the propagating houses and orchards.

[1] Hawaii Sta. Bul. 29.

REPORT OF THE ASSISTANT HORTICULTURIST.

By Chester J. Hunn.

BUILDINGS.

As noted in the annual report for 1912, a number of new buildings, more adaptable to prevailing conditions, were in the process of erection. The acquisition of these quarters has necessitated the rearrangement of the whole system of propagation and horticultural supplies. In addition to these new buildings there has been erected a number of outdoor ant-proof tables and several fences for wind protection.

The ant-proof, glass propagation building has been one of the important additions of the past year. The depredations from pests have been reduced to a minimum, while the average percentage of germination with seeds has been greatly increased. The facilities for the regulation of heat and moisture, which are of utmost importance in subtropical propagation, have been greatly augmented by the construction of hinged glass frames over the seed and cutting propagating beds. While the bottom heat derived from the solar heater has been very satisfactory during the afternoons of sunny days, there is still much to be desired, especially during the mornings and on cloudy days when the heat is not sufficient. Plans by which a gas heater is to be installed are being consummated. This should make the propagation work more effective.

FIELD WORK.

Since the scope of the horticultural work is increasing year by year, the amount of field and greenhouse work is becoming correspondingly greater. The various tree plantings have required staking, pruning, fertilization, fumigating, and spraying. Since the advent of the fruit fly (*Ceratitis capitata*) all fruit, on approaching maturity, has been covered with cloth or heavy paper bags. From time to time new plants have been placed in the fields. It has been found necessary to use heavier copper wire on the tree labels. The plant records have been kept up to date, as usual. The fields in general are in a better condition than several years ago, due to the plowing under of cover crops which are sown yearly just preceding the rainy season.

PEACHES.

The varieties of peaches as grown in California will not succeed at the lower altitudes in Hawaii. There are, however, a number of seedlings of very good quality growing on the various islands. It is the desire of the station to collect budwood of the best seedlings and to bud the same into trees in the station orchard. A number of persons have imported budded stock of the Peento and of the Honey

peach groups. This station has under test at the Kauai substation the better known commercial varieties of these two groups. During the past year this station received budwood of both a Bolivian freestone and a clingstone peach. The establishment of a peach industry on the islands rests upon the selection of seedlings, the importation of tropical and subtropical varieties, and upon the control of the Mediterranean fruit fly.

ACCESSIONS.

The varietal collections of avocados, mangoes, and citrus have been augmented by the collection of the better varieties both of Hawaii and of foreign sources. This budwood has been used in the several orchards, from which budwood can later be obtained for distribution. Letters sent to all parts of the tropical and subtropical world in regard to the papaya have resulted in the receipt of many new strains of the papaya, which are now being grown in the test orchard. Among the notable importations should be mentioned numerous packets of seed from Java and Ceylon and a collection of plants from the botanical gardens at Sydney, Australia, both of which were donated to the station by Dr. William T. Brigham, of the Bishop Museum. These include several new varieties of *Nephelium lappaceum*, *N. mutabile*, and *Lansium domesticum*.

DISTRIBUTIONS.

While this department makes no pretense of keeping a supply of plants for distribution, cuttings of the surplus hibiscus and other ornamentals, as well as seedling fruit trees, have been distributed during the past year. One of the ways in which this station can assist the general public in building up a home or a commercial fruit industry is to distribute the better varieties of avocados, mangoes, and citrus. Such plants, either budded or grafted, have been sold at a nominal figure to cover the expenses of propagation and to make the trees something to be desired. The citrus trees have been sold as "balled" budded nursery stock, while the avocados and mangoes have been distributed growing in the gallon tin containers in which they were budded or inarched. This department has from time to time filled requests made by other scientific institutions.

PROPAGATION BULLETIN.

Considerable time has been devoted during the past year to the collection of data, from actual experimental work and otherwise, for a bulletin on propagation. This publication will be amplified by the addition of lists of plants suitable for planting in Hawaii.

REPORT OF THE CHEMIST.

By W. P. Kelley.

The work of the chemical department during the year has been devoted very largely to soil investigations. In addition to the analysis of a large number of samples collected in connection with the general soil survey that has been under way for several years, a considerable number of soils have been examined for special purposes, particularly with reference to the occurrence of manganese. The pineapple growers have become so generally aware of the detrimental effects of excessive manganese that ever-increasing demands are made on the station for information regarding the amounts of manganese in the new lands that are being opened up for pineapples. Study of certain special soil problems has also occupied considerable attention; a study of nitrification and ammonification, the effects of heat on soils, the fixation of fertilizers, a study of the organic nitrogen of typical island soils, etc., being the chief problems investigated. Some time has also been given to a study of certain agricultural products, such as the rubber-containing latex from *Euphorbia lorifolia,* the kukui-nut oil, and waste pineapple juice.

SOIL SURVEY.

The meager state of knowledge concerning the extensive upland areas, and the increasing importance attached to these sections by virtue of the increased demand for new lands, have emphasized the need of securing as much information regarding these soils as possible. The general soil survey that has been under way for some time has therefore occupied a larger share of the attention of this department than during any previous year. Several hundred samples have been collected, so as to represent as completely as possible the various uplands, and these have been subjected to chemical and physical analyses. The work bearing directly on this survey is practically completed and a report on it is being prepared for publication.

The making of a soil survey in Hawaii, in the sense it is understood in the States, is extremely difficult, for the reason that soil types can not be so definitely located. Great variations occur within short distances without necessarily bearing any definite relationship to the topography. Neither can the types be traced with any degree of certainty from superficial examination. Often local spots, small in area, but peculiar in composition, are found surrounded by a number of other types. The soils of Oahu, however, have been very thoroughly sampled—so thoroughly that it is safe to conclude that all the important types have been located. On the other islands it has not been feasible to go into as much detail. A number of samples have been taken from every district, however, so that it is possible to discuss the island soils generally, with small probability of going far astray.

A number of unusual soil types have been located and considerable data have been accumulated with reference to these. It has been the purpose in this investigation, in addition to accumulating data with reference to the empirical composition of the soils from the different sections, to learn as much as possible regarding their properties, modes of formation, the trend of changes which they are undergoing, and the best methods of management.

LAVA ANALYSIS.

A number of samples of lava, representing the various lava flows of easy access, were analyzed, with the idea that the composition of the lava from which all the island soils have originated, with that of the soils themselves, would throw light on the nature and course of changes now occurring in the soils. The results of absolute analyses of the lava samples are given in the following table:

Analysis of Hawaiian lavas.

Constitutents.	From Oahu.				From Hawaii.					
	A.	B.	E.	F.	501	502	503	504	505	519
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Silica (SiO_2)	52.45	52.15	51.98	52.24	48.88	48.55	52.07	51.25	49.94	50.69
Alumina (Al_2O_3)	11.49	12.57	15.85	16.00	12.84	14.83	14.12	14.36	14.42	15.62
Ferric oxid (F_2O_3)	3.66	3.36	2.90	3.73	.30	2.44	2.64	3.30	1.04	.49
Ferrous oxid (FeO)	6.90	7.07	6.84	5.89	8.52	6.07	7.01	6.43	8.01	4.65
Manganese oxid (Mn_3O_4)	.36	.50	.92	.68	.31	.66	.72	.44	.20	.28
Lime (CaO)	10.32	8.54	9.57	9.54	9.55	8.56	10.71	10.65	11.59	11.14
Magnesia (MgO)	5.81	6.51	5.61	5.90	10.29	14.22	7.51	9.12	9.08	6.55
Potash (K_2O)	.89	.84	.97	.86	.75	.72	.74	.64	.80	.90
Soda (Na_2O)	2.44	2.64	2.70	2.65	1.44	1.56	1.93	1.96	1.79	2.56
Sulphur trioxid (SO_3)	.20	.61	.51	.53	.33	.19	.35	.33	.33	.78
Phosphorus pentoxid (P_2O_5)	.38	.28	.22	.11	.21	.22	.24	.17	.26	.34
Titanic oxid (TiO_2)	4.07	4.07	1.50	1.50	2.54	2.15	2.42	2.35	2.86	5.53
Combined water (H_2O)	1.02	.94	1.04	.54	4.45	.09	.00	.00	.00	.10
Total	99.99	100.08	100.61	100.17	100.41	100.26	100.46	101.00	100.32	99.63

A striking feature of these analyses is the close similarity in the composition of the several lava flows from the island of Hawaii. It is also noteworthy that the lavas from Hawaii on the whole are very similar in composition to the normal basalts of Oahu. The four samples from Oahu were taken from excavations recently made in the Wahiawa district, and, so far as could be judged, had undergone very little alteration since they had been laid down. The samples from the island of Hawaii, with the exception of Nos. 505 and 519, represent flows of definite dates coming from the volcano Mauna Loa, and all the samples were taken from exposed places.

Sample No. 501 came from the flow of 1823, and had begun to undergo slight alteration, as shown by the combined water and a slightly reddish tinge, in contrast to the normal dark gray color. A slight leaching had also taken place. Sample No. 502 represents the flow of 1868 and was taken at an elevation of 1,800 feet. This lava also showed slight changes in appearance, which were evidently due to hydration, slight leaching, etc. No. 503 came from the flow of 1883, No. 504 the flow of 1907, and No. 505 represents the small flow that occurred near Christmas, 1910, when the volcano Kilauea arose to near the surface, small amounts of lava having been deposited on

the ledges, from which the analytical sample was secured. The chemical composition of these different flows presents a striking similarity in the percentages of the several constituents, with the exception of the magnesia, which was found to be quite irregular, and in each instance present in larger quantities than occurred in the basalts of Oahu. The sodium content, on the other hand, occurs in smaller quantities than was found in the samples from Oahu. In other respects the lavas from the two islands are very similar in composition.

No. 519 represents a sample of the material known as "Pele's hair," which is made up of fine hairlike threads of lava, formed when bubbles of escaping gases are suddenly forced out of the molten lava of Kilauea, the explosive force being so great that small portions of the molten lava are spun out into threads, which are caught by the wind and blown some distance away. The composition of this material shows it to be quite similar to the normal lava of Oahu.

NITRIFICATION AND AMMONIFICATION.

The great importance now attached to the biological processes going on in the soils, particularly such processes as have to do with the rendering available of soil nitrogen, suggested the desirability of investigations on nitrification and ammonification. It is now well known that, while these processes are due to organisms, various chemical and physical factors exert great influence on the intensity of the changes brought about by them. The soils of Hawaii, as previously pointed out, are extremely abnormal in many respects; generally they contain unusually high percentages of iron oxid and alumina, and not infrequently abnormal quantities of magnesia. The physical make-up of these soils is also peculiar. The clay, which is present in very high percentages, is composed of substances differing in composition from normal clay. Climatic factors are also extremely variable, and sometimes very abnormal.

From preliminary studies it was found that the average soil contains a very low percentage of nitrate and rather large amounts of ammonia. In this work considerable attention has been given to partial sterilization as affecting these processes, and some interesting results have been obtained. The full details of this investigation have been brought together in a separate publication.[1]

EFFECTS OF HEAT ON SOILS.

The remarkable effects on ammonification observed to follow partial sterilization by means of heat suggested a study of the effect of various temperatures on the solubility of the soil constituents. Remarkable changes were observed to take place as a result of heating, practically all the soil constituents being greatly increased in solubility. This phase of the investigation has already been reported upon in a separate bulletin[2] and therefore need not be discussed here, further than to mention that the effects of heat on soils are extremely complicated. In addition the data show that burning very greatly affects the solubility of soils.

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[1] Hawaii Sta. Bul. 31. [2] Hawaii Sta. Bul. 30.

FIXATION OF FERTILIZERS.

The comparatively large amounts of fertilizers used in the islands, sometimes in districts of extremely heavy rainfall, suggested the desirability of securing definite data with reference to the leaching of fertilizers from the soils. The subject of fixation of fertilizers has been studied extensively in most parts of the world, but only to a limited extent on soils similar to those of Hawaii. This work is being carried out by Mr. McGeorge, assistant chemist, and is now well under way. The data already secured show that the fixing power of Hawaiian soils is remarkably high, especially for phosphoric acid. The maximum fixing power for phosphoric acid of the soils studied has not yet been determined. In some instances as much as 0.8 gram of P_2O_5 has been fixed by 100 grams of the soil without its showing any diminution in fixing power. The fixation of potash and of nitrogen in the form of ammonia has also been found to be high, but seems to reach a maximum within a comparatively short time. A point of special interest in this connection has to do with the fixation of nitrate. For many years, enormous quantities of nitrate of soda have been applied throughout the islands, sometimes in districts where the precipitation may average as much as 300 inches per annum. The data already obtained show conclusively that nitrate of soda is not retained by these soils, the leachings showing that in a very short time the nitrate passed through the soil. This naturally raises the question concerning the real explanation of the fact that nitrate of soda frequently produces enormous increase in the yields of cane, although applied in a single application at an early period in the growth of the crop. This work is being continued with a view of obtaining data on the effect of heat on the fixing power, the effects of sterilization, etc.

SOIL ORGANIC NITROGEN.

In 1911 some preliminary studies were reported from this station on the organic matter of Hawaiian soils.[1] This subject has again been taken up, mainly, however, with reference to the nitrogenous constituents. When it is recalled that practically all the nitrogen of soils exists in organic combinations, and that these are subject to various changes, induced by biological agents which seem necessary before the nitrogen becomes available for plant growth, it is at once apparent that any additional information that can be obtained regarding the changes in the chemical combinations taking place in soil nitrogen can but lead to a better understanding of the biological processes going on and may prove of great practical value. The wide range of climatic conditions in Hawaii, particularly with reference to the rainfall, affords ample opportunity for a study of extreme variations as brought about by moisture content of Hawaiian soils. Considerable areas of the islands are maintained in a practically continuously submerged condition, whereas arid areas are not uncommon. It was suggested, therefore, that a study of the hydrolytic products obtainable from soils coming from these two widely differing sets of conditions might give some indication as to the fundamental nature of the anaerobic and aerobic hydrolyses.

[1] Hawaii Sta. Press Bul. 33.

The question of the composition of so-called humus, with particular reference to its nitrogen and the humification process, have been subjects of much speculation, and apart from a few special investigations little indeed is really known about them. It is true most agriculturists consider that organic matter must undergo a process termed humification before it becomes of the greatest value to soils, but just what is implied by humification is far from being definite and is little understood. A study of humus with reference to its nitrogen, to gain some insight into the nature of the cleavages that take place during the humification process, etc., has been begun, and the results will be presented in a separate publication in the near future.

LIME-MAGNESIA RATIO.

The lime-magnesia ratio in soils is now occupying a prominent place in soil investigation throughout the world, and the results obtained to date have given rise to conflicting conclusions. Many of the island soils contain abnormally high percentages of magnesia; in fact the average soil of the islands contains considerably more magnesia than lime, while in some instances the magnesia content is several times that of lime. The soil previously used for rice experiments at the station is one of these abnormal types, analysis of which shows it to contain 1.99 per cent lime and 9.42 per cent magnesia, each of which probably exists, however, largely as hydrated silicates since the carbon dioxid content is low. Some experiments have been carried out in pots, employing varying amounts of both the carbonates and the sulphates of calcium and magnesium, and observing the effects produced on the growth of rice. It will be recalled that some years ago Loew and his coworkers in Japan studied this question extensively with reference to rice and drew the conclusion that a more or less definite ratio of 1:1 was best suited to the growth of rice. Two sets of experiments on this subject have been carried through, the results of which are in conflict. The first series showed that the larger application of magnesium sulphate caused a decrease in the yield, whereas that of calcium brought about an increased growth. In the second set of experiments no such effects were observed, although much larger amounts of these constituents were employed. These results are somewhat puzzling, and no explanation is offered at this time.

It is noteworthy that the use of carbonate of magnesium caused a considerable delay in the maturity of the rice, in harmony with the findings of Voelcker,[1] at the Woburn station. Further comment on this question is reserved for a subsequent publication dealing with the effects of lime and magnesia on ammonification, nitrification, etc.

RUBBER INVESTIGATIONS.

The discovery of the occurrence of large amounts of latex in the tree *Euphorbia lorifolia* called for some study. The latex was found to contain a low content of rubber, but high percentages of two resins. This work has already been published in a press bulletin from this station.[2]

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[1] Jour. Roy. Agr. Soc. England, 73 (1912), pp. 325–338.
[2] Hawaii Sta. Press Bul. 37.

KUKUI-NUT OIL.

The enormous quantities of kukui nuts (*Aleurites triloba* or *A. moluccana*) going to waste throughout the islands suggested the desirability of some study of the oil content in the nuts. Formerly this oil was expressed by the natives and found considerable favor. The nuts were found to contain practically 60 per cent of a quick-drying oil, and the several constants have been determined, as well as its general properties. This work has likewise already been published in a press bulletin.[1]

PINEAPPLE VINEGAR.

In the canning of pineapples, now so extensively carried out in the islands, there is enormous waste of essentially pure pineapple juice, amounting to hundreds of thousands of gallons per annum. For some time past some of the canneries have utilized the waste juice in the making of sirups, and, to a limited extent, for the production of bottled pineapple juice. Notwithstanding these uses, a large amount of this juice is still going to waste. An appeal was made to the station for some assistance in connection with the possible utilization of the juice for the making of vinegar.

The Hawaii Preserving Co. had already erected a series of tanks similar to those used elsewhere in the quick vinegar process, and a series of experiments was carried out in cooperation with this company, using their plant. The results were not entirely satisfactory. On an average the vinegar obtained contained an acetic acid content of about 3.8 per cent, which is considerably below the legal standard. Occasionally it was possible to obtain vinegar of approximately $4\frac{1}{2}$ per cent. The difficulty in this connection appears to be that anything like complete alcoholic fermentation of the sugars in the ordinary juice is extremely difficult to obtain, due to the fact that various other types of fermentation take place simultaneously with it. It is necessary first of all to sterilize the juice soon after it is expressed, and as yet no thoroughly satisfactory method of alcoholic fermentation of the juice has been worked out on a commercial scale. There is no doubt that a vinegar of excellent quality can be obtained provided satisfactory alcoholic fermentation be first secured, but since acetic acid fermentation is dependent first of all upon the alcohol present, a satisfactory vinegar, of course, can not be obtained until the desired concentration of alcohol is first secured. The small price of the product when once it was obtained did not encourage further investigation of the question, but it is hoped that a more extensive study of the question will be undertaken at some future time.

Much of the success of the work of this department is due to the efficient assistance rendered by Mr. McGeorge and Miss Thompson, assistant chemists, and a large share of the credit belongs to them.

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[1] Hawaii Sta. Press Bul. 39.

REPORT OF THE AGRONOMIST.

By C. K. McClelland.

The work in the department of agronomy has been carried on under several handicaps during the past year. One of these was the loss of the rice plats and the necessity of preparing new lands for rice experiments. The lands obtained for this purpose in Nuuanu Valley were abandoned taro patches, grown over with Bermuda grass, coco grass, honohono, and weeds. Three plowings at extended intervals were necessary in order to put this land in shape for cultivated crops. By the time this was done it was too late to put in a fall crop of rice, and corn, soy beans, oats, barley, and peas were planted. In March of the present year rice was planted over part of the area where the soil appeared to be uniform. To test the soil of the new location a fertilizer test was started upon one plat, while upon two adjacent plats a simple test of deep versus shallow submergence was inaugurated. Further experimentation with rice will be made along the lines of rotation of crops and methods of soil management, and no further attention will likely be given to variety trials.

RICE.

As has been mentioned in previous reports, the station has been attempting for some time to produce a rice of a quality equal to that of the imported Japanese rice, and which would be acceptable to the Japanese population. Four varieties were recently introduced for this purpose. After being grown for several generations they have been found wanting, and the attempt to produce rice of this quality will have to be abandoned. The Miyako variety was tested after being grown for three generations, and was found to be greatly deteriorated. The Omachi and Shinriki varieties, after having been grown for five generations, were submitted, with samples of imported rice, to three representative Japanese and also to three Americans who, from residence or sojourn in Japan, were qualified to act as judges of Japanese rice. One of the Americans admitted his inability to distinguish between the three samples, but found them all superior to ordinary Hawaiian-grown rice. The other five selected one of the samples, which proved to be the sample of the imported rice, as being greatly superior to the other two samples. This test proves beyond any doubt that there is a great difference in quality between Japanese-grown and Hawaiian-grown rice, and also proves to our satisfaction that it is vain to attempt to produce a rice equal in quality to the Japan-grown article. While it has been shown that there is no difference in chemical composition, the judges who made this test for the station have pointed out that the differences are in physical and culinary qualities. When cooking, the Hawaiian-grown rice absorbs more water than does the other, while upon cooling it seems

to give up its moisture and becomes more dry and less palatable. There is also a difference in the taste, in the smell, and in the touch of the rice when cooked, and the palatability is greatly in favor of the Japan-grown rice.

CORN.

The work with corn has been more satisfactory during the past season than for three years previous. The rainfall has been heavier, and this has been quite favorable for the corn. In Nuuanu Valley yields were obtained varying from 37 to 60 bushels per acre. It has been demonstrated that at the elevation of the station it is possible to produce corn only from fall or early winter plantings. The yields which have just been mentioned were obtained from corn that was planted in November. Corn that was planted in March was so badly attacked by aphis and leaf hoppers that practically no yields were obtained. Where corn is in small patches and isolated from crops of this kind immunity from attack for the first season may occur, but this immunity is not likely to be continued. At the same time that corn upon the station grounds was suffering from the attacks of these insects a small plat of sweet corn in Nuuanu Valley was not troubled in the least and matured a crop which came off in about the middle of June.

Several different varieties of corn were obtained from the mainland for trial, but because of late planting no definite results were obtained as to which varieties were the better. Small lots of seed of the different varieties were sent to the Kula region of Maui to be tested in the corn district there. The interest in the question of corn cultivation is being increased throughout the islands, and the various ranches are undertaking the cultivation of larger areas in corn for the purpose of supplying feed for their stock during long periods of drought.

It is the intention to erect silos in which to preserve the corn, and it is hoped by means of the silo and of silage to prevent much of the loss which has heretofore occurred during such long periods of drought.

Other crops which are valuable for use in the silos are sorghums, Japanese cane, and the cane tops from the sugar plantations. Experiments will be made also with various legume crops, such as velvet beans, jack beans, cowpeas, soy beans, and alfalfa, in an attempt to improve the quality of silage. Several silos have been completed and others are in process of construction on various ranches and still others are talked of, so that within a few years it is thought there will be quite a number in use in the Territory. Because of the interest in silos and silage crops, two press bulletins were issued, one upon Corn Culture and Improvement,[1] and the other upon Silos, Silage, and Silage Crops for Hawaii.[2]

EXPERIMENTS WITH SMALL GRAINS.

During the year an experiment was made with three varieties of barley and with nine varieties of oats. The varieties of barley were known as Champion Beardless, Oderbrucker, and the ordinary six-rowed bearded barley. The varieties of oats included a white and a

[1] Hawaii Sta. Press Bul. 42. [2] Hawaii Sta. Press Bul. 40.

red variety obtained from seedsmen in San Francisco, and also the following varieties from the substation at Denton, Tex.: Red Rust Proof, Red Siberian, Red Algerian, Burt, Winter Turf, Ninety Day and Sixty Day oats. This experiment with small grains was very unsatisfactory. The plants furnished an immense amount of green forage, but later in the season a part of this died down, after which the remaining plants threw up seed stems and made a little seed. In each case the heads formed were very short and the seed was very poorly filled out. With the oats not as much seed was obtained as was planted. The barley did a trifle better and yielded about an equal amount to that which was planted. The white oats were earlier and yielded better than the red oats, but were badly attacked by rust. The red oats were uniformly late and remained green to a much later date than did the white. They produced a much smaller amount of seed and were not badly attacked by the rust. It would seem from this test that small grains can not be profitably grown at the elevation of the station, although from time to time volunteer oats at different places seem to make excellent growth.

GRASSES AND FORAGE CROPS.

Tests have been continued with various grasses. Many of the seeds planted failed to grow. Some of those which started failed later on account of lack of moisture. Frequently it happens that the moisture supply is sufficient to start the seed, but the surface dries so rapidly that the supply of moisture is exhausted before the roots are long enough to obtain moisture from the deeper soil. This fact, together with the poor seed, accounts for nearly all failures to obtain a stand with grasses. The new grasses most promising for hay and soiling crops, as a result of this year's test, were Natal redtop, Australian bluegrass, Tunis grass, and Sudan grass. The two latter grasses, of which the Sudan is seemingly the better, have been sent to several ranches for trial. Upon the station grounds they were planted February 20, and 55 days later they had reached a height of 4½ to 5½ feet and had commenced to head out. These grasses are related to and resemble Johnson grass, but are without any underground stem, so that there is no danger of their becoming a pest, as is the case with Johnson grass. They are very palatable, and horses consume even the coarser stems of the grasses. The seed is of good size, heavy, and there is no trouble in securing a stand. How well these grasses will withstand grazing, repeated cutting, or drought, and whether or not they can persist and spread on a range will have to be determined by further trial, but they seem to be excellent for hay purposes. The seeds, if left until all mature, will be molested by birds.

The Natal redtop and Australian bluegrasses are much shorter than the preceding, growing only 24 to 30 inches high. They seed freely within three or four months after planting when not grazed. Not all of the seed, however, is good; with the redtop especially it has been difficult to secure a stand, only 5 per cent or less of the seed being viable. The redtop seed requires some little time for germination, even when good.

The best pasture grasses among those which were tried were doubtless the rescue grass, also known as Australian prairie grass, Texas bluegrass, and one called *Phalaris commutata*, the common name of which is not known. These grasses were planted along with what is here called buffalo grass in a field badly infested with coco grass or, as it is sometimes called, Japanese nut grass. All these grasses seem to be vigorous enough in their growth to overcome the coco grass, holding it in check and making valuable grazing.

Neither the Texas bluegrass nor the *Phalaris commutata* has produced any seed, although planted for 7 months, and they are seemingly best propagated by divisions of the root. The rescue grass, on the other hand, seeds freely, and is easily propagated from seed.

COTTON.

The main field of Caravonica cotton is still in cultivation, the plants being now in their fourth year. The yield in 1912 was very light, owing to the continued dry weather. The spring crop was picked by the middle of July, and there was no further crop, owing to lack of moisture. The spring crop for 1913 has been quite large, and has been picked and the plants were cut back for a later crop.

The work with Egyptian cotton, which was carried on last year at the Honolulu School for Boys, has been given up since the variety does not seem to produce as well as the Caravonica or the Sea Island.

During 1912 the Sea-Island cotton also failed to produce a profitable crop. About one-fifth of an acre was left and the balance was uprooted. A small area on an adjoining field was planted in February, 1913, and this year a comparison will be made between new plants and the ratoon crop from last year's plants. Heretofore the ratoon crop from the Sea-Island cotton has never turned out well, but the present crop seems to be more promising.

The pink bollworm still continues its ravages, and there is little hope of any cotton industry in Hawaii until some remedy has been found for this pest. The cotton areas in the islands are growing less instead of greater. The 50-acre field at Mokaweli, on Kauai, has been uprooted since no profitable crop has been obtained in three seasons, owing to dry conditions and to the bollworm. There remain still on Kauai perhaps 50 acres in cotton, in the Kona region of Hawaii perhaps 75 acres, in the Koneohe district of Oahu about 80 acres, and in the Waianae district possibly 30 acres.

SORGHUMS.

An experiment is under way testing out several varieties of sorghums of African origin received from the United States Department of Agriculture.

With these have been planted two sweet sorghums, Early Amber and Sugar Drip, and also the No. 309 previously mentioned in an annual report as being noteworthy. The latter variety to date leads all of the other 23 varieties.

The No. 309 and Sugar Drip varieties are also planted in a comparative test with Japanese cane to determine which will produce the largest amount of forage within a given time.

SWEET CORN.

With sweet corn some profitable crops were raised. This corn retails at 30 cents per dozen ears, and sells wholesale at 18 to 20 cents. The market demand at times is keen, but usually a small supply stocks the market and then no corn can be sold at any price. The variety grown at the station was very prolific and required 75 to 80 days to reach roasting-ear stage. The ears were usually 6 inches long with 8 rows of broad kernels. This corn was of excellent quality; from catalogue descriptions it might be White Cory. Several plantings were made between November 7 and March 27. Yields were from 533 to 1,436 dozens per acre. At 18 cents per dozen it will be seen that the crop paid well for the short time the land was in use to produce it.

IRISH POTATOES.

Successive plantings of Irish potatoes from November 7 until March 7 show that better yields are obtained by planting at the latter date. The fall planting was attacked by a root-rot fungus, *Rhizoctonia* sp., and by another root or stem rot known as *Sclerotinia rolfsii*. These diseases attacked the plants in the early to medium stages of growth and destroyed them. They are recognized by the wilting or deadening and blackening of the stem from the root to several inches above the surface, killing the plant before any tubers become of proper size. Neither the Burbank nor the Triumph seemed able to withstand them. These fungi are more destructive on early planted potatoes and in wet weather. The later planted crops were not so badly attacked by root rot, but were killed by blight. The Early Rose, Bliss, Triumph, American Wonder, and Burbank were tried later, but none of them could be maintained alive for a period long enough to make good potatoes, even with three sprayings of Bordeaux. One planting which was harvested 98 days after planting commenced to rot within a few days after digging. The early potatoes, Early Rose and Triumph, when left in bags were rotted so badly as to be unsalable. These potatoes were larger and more nearly mature than those of the other two varieties, but seemed to rot more quickly. In this test it was also noticed that there was more loss from rot where the potatoes were left in bags than where spread out in a thin layer on the floor and given ventilation.

Those who have investigated the subject on the mainland advise leaving blighted potatoes undug until two weeks or more after the vines are dead, so that the spores will not get on the potatoes, where they would cause rot. Potato digging there, however, takes place in cooler season, with increasing coolness, while in Hawaii the crop matures in a season which is constantly growing hotter, and if the potatoes are left in the soil great loss will occur from rot. Perhaps, however, frequent rains had washed the spores down on to these potatoes in the soil. In a dry season it may be possible to leave the potato for a longer time, but this year the planting of March 7 was dug on June 16, the potatoes having commenced to rot in the soil.

Experiments with various sized seed pieces were made, but the yield in most cases was determined more by the number of days' growth before blighting than by the seed. Selections were made, but at this altitude it was found impossible to keep them over.

SUBSTATIONS

The two substations with which this department has been directly cooperating are at Waipio, Oahu, and at Kula, Maui.

At the Waipio substation failure is again to be reported, due to lack of moisture. No rains occurred until late in April—too late to help out the crops under trial. On this farm pineapples are being planted to replace the cotton, but several crops have been tried upon small areas. Oats and barley made a poorer crop here than upon the station grounds. Alfalfa seems always to suffer from attack of cutworms; the former area was replanted and an adjoining strip was dynamited and planted, but the resulting stand is very imperfect.

In a long period of drought, such as has prevailed here for over two years past and has but recently been broken, it is hardly worth while to attempt the growing of any ordinary crops, even pineapples being extremely slow to start growth in such dry soil. The failures here include broom corn, Kafir, milo, jack beans, velvet beans, soy beans, pigeon peas, onions, watermelons, and Irish and sweet potatoes.

In Kula some experiments have been started with small grains, corn, sorghums, Japanese sugar cane, Irish potatoes, and various legumes. A resident of this district is authority for the statement that within his sojourn 32 out of 33 crops of potatoes have been greatly reduced in yield from either drought, attacks of cutworms, or blight. The experiments being made this year are principally for control of blight by spraying, but if seed can be preserved from one crop to the next an attempt will be made to improve the crop by selection. Likewise with corn, it is hoped that some improvement may be made by selection and ear-row methods. A silage experiment, carried out in an abandoned cistern, turned out very satisfactorily and has demonstrated to the community at large the value of silage. Experiments are now being made to test out the comparative value of corn, sorghum, Japanese cane, and various legumes for silage.

An attempt at growing winter cover crops has already been made, but as the work did not begin until the first of the present calendar year and partly because of dry conditions, the crops were not large enough to withstand the dust storms and were destroyed.

In the past a wasteful system of farming has been practiced in the Kula corn belt. Following the practices of the farmers in the corn belt of the United States, the corn planters of Kula have been accustomed to take from the fields only the grain. Afterwards what few animals they had were pastured on the cornstalks—then later the stalks and husks were burned, the land plowed, and another crop planted. It was only after such a burning that good clean plowing could be done, and it was desirable to burn the stalks to facilitate the cultivation of the following crop. Gradually this evil practice is being corrected. The stalks only are burned, the husks and leaves being turned under. Some are cutting up the stalks with stalk cutter or cane knives, and turning all trash under. This is the proper method and the only improvements upon this are the use of the silo, as mentioned above, and the use of green-manure crops, which will be explained.

Those familiar with conditions in Kula maintain that the dry summer and fall of 1912 was very exceptional, that ordinarily a fall

crop of potatoes is grown, and that other things could be planted. This suggests that cover crops can be grown to advantage with and following corn. All of the crops suggested below can be planted in the corn with a small amount of labor, and some of them require but a small outlay for seed. The benefits to be derived are as follows:

(1) Additional feed for horses, cattle, or hogs.

(2) Prevention of soil washing or leaching during heavy winter rains.

(3) Prevention of at least a part of the blowing of the soil common in early spring.

(4) Improvement of fertility and moisture-holding capacity of the soil by the addition of more vegetable matter as dry or green manure when the land is plowed.

Cover crops may be classified as nonleguminous or leguminous. (1) Nonleguminous crops for pasture or hay and for green manure. The crops best suited for this purpose and the seed of which would be quite inexpensive are the small grains—wheat, rye, oats, and barley. All of these would furnish some grazing during the winter months and could be turned under in time for planting in the spring and would benefit the land as above explained.

There is a small 5-hoe or disk drill costing about $15, made especially for drilling between corn rows. It plants several acres a day and one might suffice for several adjacent small farmers. In the absence of such a drill the grain can be sowed by hand and worked in with single row cultivators or small plows, but the saving in seed by use of the drill would more than pay its cost. Which grain to plant and at what time to plant it are questions which must be worked out by experiment, and some judgment must be used by the planter as conditions in different seasons vary greatly. Probably wheat or rye will be found more suitable for early planting (September or October) and oats or barley for later planting. These may be grazed at times when the soil is dry enough to permit, or they may be cut when still green in the spring for hay. When pastured or cut there is less to turn under for green manure, but it is better to turn under a smaller amount every year than an excessive amount in any one season. If land is prepared for early planting, also, the amount turned under will be less and the benefit of protection from leaching or blowing will necessarily be somewhat reduced in amount.

(2) Leguminous crops for hay, pasture, and green manure. The advantage of these crops over the small grains is that they are able to obtain nitrogen from the air, and to this extent they excel the grain crops for green manuring and improvement of the soil. Not all of them will stand grazing. Many do not so well protect the soil from leaching or blowing, and with all of them the seed is more expensive. Probably the use of these crops will not become common until after the others have been tried and their great value noted.

Cowpeas are one of the most valuable legumes for planting with corn. Throughout all of the Southern States it is now the common practice to sow cowpeas in corn, and usually this is done at the time of the last cultivation or the "laying by" of the corn. They may be sown by hand and covered with the cultivator or may be drilled midway between the rows with the single row corn drill. When this is done another cultivation of corn and peas is usually given. These

may be sown in the South, then, from May until August. Enough ripe pods are picked to insure plenty of seed for the succeeding year, after which cattle and hogs may be turned in to harvest the balance. In Hawaii, at lower elevations at least, these may be planted in the fall months, and since parts of Kula are below frost line, no doubt they can be grown there during the winter months. The seed is expensive, but, as stated, seed may be saved from year to year, when a start is once established. Cowpeas are attacked by cutworm and aphis.

Colorado stock pea or Canada field pea can be grown probably only during the cooler months of the year. It is often planted with oats for the "oat and pea" hay crop. Whether or not it will thrive and produce a good seed crop must yet be determined.

Soy beans can be easily grown at any time when there is sufficient moisture to start the seed. Some varieties, however, produce little vine. A coarse growing variety should be obtained, if possible, for green manure.

Peas and beans are of great value as feed and for enrichment of the soil, but of less value as cover crops or for grazing.

The clovers, including crimson, bur, Egyptian, and possibly red clover, are all of great value and do well during the cooler months and the rainy season. They are not suited to hot, dry conditions. Bur clover is much more likely to reseed itself and for this reason should be given a thorough trial. It is also the better for grazing, and less valuable for hay, since it is more prostrate in its habit of growth. Inoculation may be necessary, but the first three named thrive without it on Oahu.

These are the legumes of greatest value for stock feed, but white navy beans, dwarf Lima beans, or other garden beans could be grown after or with the corn crop with profit.

REPORT OF THE ASSISTANT AGRONOMIST.

By C. A. Sahr.

EXPERIMENTS WITH LEGUMINOUS PLANTS.

About two years ago this station issued a bulletin on leguminous crops for Hawaii,[1] in which a report to date was made upon alfalfa, soy beans, cowpeas, pigeon peas, jack beans, and velvet beans. A press bulletin upon peanuts was also issued.[2] Since then more or less attention has been given the various leguminous crops recommended for future trials, keeping an available supply of seed on hand, studying the relative value of different species, when grown under various conditions.

The seed of many new varieties of legumes have been received and tested with varying success, according to their adaptabilities to Hawaiian conditions and general value in rotation. These include soy beans, sword beans, velvet beans, horse beans, asparagus beans, sesbania, kulthi, sunn hemp, stock or field peas, and a variety of Cuban peanut.

To facilitate the selection of leguminous seeds for planting in their relative order of importance for rotation, green manure, forage, hay, and seed crops, the following classification is suggested:

I. Quick rotation, short season, 3 to 4 months:
- Kulthi or horse gram.
- Cowpeas.
- Sunn hemp.
- Mungo beans.
- Soy bean, seed varieties.

II. Medium time, 4½ to 6½ months:
- Soy bean, coarse variety.
- Peanuts.
- Pigeon peas.
- Asparagus bean (sasagi).
- Horse beans.
- Sword bean, early variety.

III. Long period of growth, 7 to 9 months:
- Jack beans.
- Sword beans.
- Velvet beans.
- Sesbania.
- *Dolichos lablab.*

INOCULATION.

Experiments with artificial cultures of root nodule bacteria were tried with negative results. Plants in untreated soils thrived as well as those in inoculated soil, the number of nodules per plant not lacking in either case.

The sufficient supply of bacteria in Hawaiian soils is probably due to the great number of wild and cultivated legumes found everywhere. Soils known to be devoid of nitrogen-fixing bacteria can easily be inoculated by the application of soil from a nearby inoculated field.

[1] Hawaii Sta. Bul. 23. [2] Hawaii Sta. Press Bul. 28.

From 400 to 500 pounds of such soil applied evenly and thinly is ample for 1 acre. Because of the harmful effect of direct sunlight upon the bacteria, soil applied should be harrowed in thoroughly and quickly.

Several artificial cultures are now on the market, any of which might prove valuable for certain legumes.

STIZOLOBIUM PACHYLOBIUM.

Seeds of this species were received from the Hawaiian Sugar Planters' Experiment Station under name of Brazilian velvet bean, but the variety should be called the fleshy-pod bean in order to conform to the classification of the Bureau of Plant Industry.[1] This is the latest Stizolobium introduced in Hawaii. The vines are stout and less erect than any other velvet bean, as was shown in a comparative test with Florida, Mauritius, and Lyon beans. Its rank growth exceeds that of the Lyon bean, which was formerly considered superior to the velvet bean. The vine blooms in 3 to 5 months after sowing, dry conditions tending to hasten the flowering and maturity, resulting in heavier yield of seed but lighter yields of hay or forage, as the leaves shatter and fall before the pod matures. Two trials were made during a long period with almost no rain at all, in light gravelly soils. Both crops matured in about 200 days. The plants took up only a part of the 8-foot space allowed between rows and blossomed at 3 months. At maturity all leaves were gone, only the vines and pods remaining. The pods run 30 to 50 in cluster, are very fleshy when green, with slight gray pubescence. When mature the pods are 3 to 4½ inches long, black, pod valves with two prominent ridges one-fourth inch apart, and several slight secondary ridges. The seeds are large, flattened, mottled gray and brown on white, 6 to 8 seeds in a pod. Under wet conditions the vines remain green and thrifty after pods mature, while but 5 to 8 pods, with 4 to 6 seeds in a pod, make up the cluster.

SWORD AND JACK BEANS.

The Canavali species tried out include No. 655, a Cuban variety, received from Mr. G. P. Wilder, under the name *C. gladiata*; No. 748, received from a local Japanese, under the name *C. incurva*, and five varieties from the Bureau of Plant Industry.

No. 655, *C. gladiata* (sword bean). Vines of very low growth and twining habit. Planted in July, very few flowers set pods, first mature pods late in February, few more by April 15; stems very slender, leaves small, glabrous, flowers reddish purple, pods thick and fleshy, 4 to 7 inches, seeds 6 to 8, dark brown. Plants start too slowly for field cover, but may be useful in covering unsightly walls or fences.

No. 748, *C. gladiata incurva* (sword bean). Like No. 655 in habit; somewhat more spreading and faster growth, flowers waxy white, few blossoms setting pods, blooms late. Two seeds sown November 20, 1912, now producing pods of which none have yet matured. Pods thick, fleshy, 9 inches long, 1½ inches wide, seeds deep scarlet red.

No. 750, *C. gladiata incurva* (sword bean). Seeds received March 17, 1913, from Bureau of Plant Industry, No. 19990, from Japan, sown

[1] U. S. Dept. Agr., Bur. Plant Indus. Bul. 179.

April 10, 1913, now producing pods. Slow growth at start, becomes rambling vine. Runners very thin and wiry, prostrate, flowers white, pods thick, fleshy, seeds white, distinctly keeled at ends, hilum long.

No. 754, *C. gladiata incurva* (sword bean). Received March, 1913, from Bureau of Plant Industry, No. 19991, from Japan. Planted April 10, 1913, and now producing pods, growth quicker than No. 750, vines prostrate, flowers large, purplish pink, pods recurved with broadened dorsal suture; seeds distinctly keeled at ends and back, elliptical, somewhat flattened, color reddish clay.

No. 755, *C. gladiata incurva* (sword bean). Received March, 1913, from Bureau of Plant Industry, No. 27704, from China. Planted April 10, 1913, leaves somewhat more leathery than No. 754, runners thicker, shorter, not yet in bloom. Seeds large, plump, distinctly keeled, deep red in color. Evidently this variety and Nos. 655 and 748 are late maturing, and may be used as cover crops only in long rotation.

No. 753, *C. ensiformis* (jack bean). Received March, 1913, from Bureau of Plant Industry, No. 21609 from Brazil. This and No. 756, received under No. 01683 from Texas, were planted for varietal test. The vines of each are erect, coarse and stubby, blossoms purple, but vines are not far enough along to note their adaptabilities apart from the jack bean grown by this station for several years past. The feeding of jack-bean fodder to cattle and swine has been attended with varied success in Hawaii, while the feeding value of sword bean has not yet been ascertained. As a cover crop the Indian variety with red seeds and red flowers has proved very satisfactory in Porto Rico. Cattle are said to graze on the plant there to a limited extent.[1]

SUNN HEMP.

No. 575, *Crotalaria juncea* (sunn hemp). Received from the Guam Experiment Station, island of Guam. Stiff shrub 3 to 5 feet high, stock fibrous, leaves linear-oblong, flower bright yellow, large, pods, 1¼ inches long, pubescent, 10 to 15 seeded, grown for hemp in India and Malay Isles.

Tests with sunn hemp carried out in the Philippine Islands in 1907–8 attracted considerable attention because of the prolific seeding habit. One plat measuring 364.5 square meters, planted in rows 0.5 of a meter apart, produced a yield of seed equal to 2,395 kilograms per hectare [2] (2,133 pounds per acre).

A small quantity of seed was run through a corn-grinding mill and the product screened through a close-meshed wire screen, thus separating the smaller particles, or bean meal, from the larger, or bean hulls. The bean meal constitutes 70 per cent and the been hulls 30 per cent of the total weight. Samples furnished the Bureau of Science showed the following analysis:

Analysis of sunn hemp seed.

Contents.	Meal.	Hulls.	Contents.	Meal.	Hulls.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Moisture	9.66	12.42	Nitrogen-free extract	28.06	54.52
Ash	6.72	4.88	Crude fiber	7.86	17.37
Protein	43.86	9.81	Ether extract	3.84	1.00

[1] Piper, C. V., U. S. Dept. Agr., Bur. Plant Indus. Circ. 110.
[2] Philippine Agr. Rev., 2 (1909), pp. 25, 26.

Some of the ground seed was fed to stock in small quantities, but tests have not been sufficiently extensive to justify any positive assertions in regard to its possibilities as a stock feed. Horses did not seem to relish it when fed alone, but when mixed with an equal part of oats or Indian crushed feed, they ate it fairly well. Cattle ate the bean meal greedily at first, but seemed to tire of it in two or three feedings. The bean meal was also fed to hogs at various times and was always eaten readily, but owing to a lack of feed in sufficient quantities no systematic feeding tests have been made.

Under Hawaiian conditions the plant made a shorter, more shrubby growth, attaining 3 feet when drilled in rows; broadcasting the seed produced tall, slender plants, 4 to 5 feet high, before setting pods, at the end of 60 days. As the leaves begin to fall shortly after the stand is in full bloom its value as a green manure crop will be materially lessened unless plowed under about the time the stand attains its full flowering stage.

SOY BEAN.

While several new varieties of soy beans (*Glycine hispida*) have been tried out by the station since the publication of the bulletin on leguminous crops for Hawaii,[1] all varieties there recommended were grown further in order to supply the demand for seed. Soy beans were grown more or less extensively by Japanese farmers in Kona, to defray expenses while their coffee trees came into bearing, finding a ready market for culinary purposes and also among local soy sauce brewers. Since the coffee orchards now demand the entire attention of the growers, the soy brewers depend upon soy beans imported from Japan for their supply.

The brewing of Japanese soy sauce having become a well-established industry in Hawaii, a visit of inspection to several of the largest factories was made to ascertain the method of manufacture, which is given here briefly. The soy beans are first boiled in large iron vats, from 4 to 6 hours, then left to cool for 18 hours. The mass is then mixed with an equal amount of California wheat, which has been browned in pans and coarsely ground. The mixture is then poured into molds, and left to stand for three or more days, or until slightly covered by mold fungi. The molds are then emptied into large cedar vats of 500 to 800 gallons capacity; a starter made from cass and brine is then added, and the mass is left to ferment for a period ranging from 6 months to a year or 18 months, the mass being thoroughly stirred twice each day. The fermented mass is then transferred into a large press and the liquid sauce is pressed out, boiled 2 or 3 hours, and put in cedar tubs of 4½ to 6 gallons capacity.

While all manufacturers use equal parts of soy beans and wheat, the density of brine differs in the cheaper and better grades of soy sauce. One manufacturer uses 800 pounds of island salt dissolved in 350 gallons of water to 1,000 pounds of soy beans, producing about 350 gallons of soy sauce when brewed. Another soy brewer uses 500 pounds salt dissolved in 150 gallons of boiling water to 400 pounds of soy beans, producing about 240 gallons of soy sauce and about 600 pounds of cass, or soy leavings. One soy brewer uses 4 bushels of salt dissolved in 200 gallons of water to 500 pounds soy beans, while the brewer of a recently equipped, up-to-date brewery uses 300 pounds of salt dissolved in 200 gallons of water to 600 pounds soy beans, producing 200 gallons of soy sauce and 800 pounds of cass.

[1] Hawaii Sta. Bul. 23.

The ferment starter is made of a small quantity of soy-bean cake, or cass, sprinkled over a few handfuls of parboiled soy beans and left in a warm place for several days. The cass is sold for 20 cents per 100 pounds to rice planters as fertilizer, and contains about 20 per cent salt. It is also fed to hogs, after soaking in water to draw out the salt. The brewers buy imported soy beans at $72 per ton in Honolulu, wheat at $40, and salt at $10. The tubs in which the soy sauce is put up are made of Japanese cedar, shipped knocked down from Japan, and put together as wanted. The cost per tub is from 40 to 70 cents, according to their capacity, which ranges from 4½ to 6 gallons. Soy sauce is eaten by all classes of Japanese as a table sauce, with their rice, fish, and meats. It has the color of strong black coffee.

Miso, another Japanese table sauce, is brewed from soy beans and rice. The brewed liquid is clear white. The climate of Hawaii is too warm for its manufacture, since the fermentation, like that of "sake" (brewed from rice only), requires a very low temperature, which can not be produced without the aid of refrigerating machinery.

While soy beans do well in Hawaii with but little moisture other than to start growth, success with rank and coarse growing varieties when grown for hay or fodder, is only attained under cool and moist conditions. Thus No. 210 and 211, classed in the above bulletin of the station as late rank-growing varieties, requiring 130 to 150 days to mature under wet conditions, will make a low and shrubby growth and mature in 90 to 100 days under dry conditions. Early varieties, however, mature in 85 to 100 days. Their growth, whether erect or bushy, does not become rank, even though the plant does not immediately die when pods mature under wet conditions, but may live for some time when loss of seed may occur through shattering.

Plate III illustrates No. 635, Otootan, grown from seed received from the College of Hawaii in May, 1911. This variety is undoubtedly the coarsest, rankest growing soy bean ever grown by this station. It is also most tolerant of both dry and wet conditions, but only makes a rank growth during a cool and moist growing period. Under dry conditions this variety makes a spreading, shrubby growth, gaining a height of 2½ to 3 feet, spreading 2 feet upon a side. The yields are prolific, 15 feet of running row yielding 3 pounds of seed, pods maturing in 80 to 90 days after sowing. When growing under wet conditions the growth of this soy bean varies, some of the plants immediately assuming a coarse, viney growth, which after gaining a height of 3½ to 4½ feet become spreading, the vines attaining a length of from 5 to 8 feet, blooming profusely, but setting few pods. Other plants make a thick, erect main stem, 3 to 5 feet high, with 4 to 8 branches, more or less twining, setting 4 to 6 pods in a single axil, maturing late. The flowers are small, purple; pods, 1½ to 1¾ inches long, deep brown; pubescence, tawny; seed, 3 to 4, black, globular. Vines mature in 130 to 150 days in winter. Trials of this variety made at Hilo and Glenwood substations resulted in coarse growing vines, 4 to 6 feet long, attaining a height of 3 to 5 feet, but failed to set pods. Vines can be cured as hay in 2 to 5 days under good conditions. The cured hay, comprising approximately 25 per cent of the green weight, when fed to mules was readily eaten.

The following table shows the relative value of different varieties of soy beans when grown for hay and forage.

Calculated acre yields of soy beans from 20 feet of running row cut for hay and fodder.

Agronomy accession Nos.	Height.	Spread.	Number of days after sowing.	Distance between rows.	Acre yield, green manure or fodder.	Cured as hay.	Yield of seed.	Stage of growth.
	Inches.	*Inches.*		*Feet.*	*Tons.*	*Tons.*	*Pounds.*	
635	33	30	81	2	11.97	2.99	.....	First blooms.
635	36	22	90	3	7.26	1.13	.....	Full bloom.
635 and cowpeas[1]	30	36	90	3	11.97	2.45	.....	Do.
635 only	42	30–60	124	2½	17.04	4.15	.....	Last blooms.
211 (S.P.I. 20798)[2]	18	14–16	52	2	5.98	.81	.....	Seven days before first blooms.
809 (S.P.I. 19183)	24	20–22	52	2	8.16	1.08	.....	Pods half grown.
698	18	17–22	81	2	7.00	1.10	1,960	Pods mature.
483 (S.P.I. 14953)	23	27	81	2	8.16	1.72	.....	Pods two-thirds grown.

[1] First pods of cowpeas matured, soy beans still heading out above cowpeas.
[2] Described in Hawaii Sta. Bul. 23. Planted beside No. 809 for comparison.

No. 698, Russian soy bean, was received from S. R. Cope, London. It is a small, erect, shrubby plant, 16 to 19 inches high, spreading 9 to 11 inches; flowers white, very prolific, matures in 80 to 90 days; about 10 per cent of leaves turn yellow in 80 days and 80 per cent fall in 85 days; pods mature in 80 days, slightly shattering.

Seven varieties received from the College of Hawaii were planted in a heavy black clay soil; started well, but failed to grow, owing to severe dry conditions. No other station fields were available for trial planting at the time; however, Nos. 635, 210, and 211 yielded well, but did not make rank growth. Other old varieties grew well, considering conditions that prevailed.

Eight varieties received from the Bureau of Plant Industry, under Nos. 19183, 22379, 32906, 32907, 34857, 34934, 34924, 34987, and 34123, were planted, two rows each in a medium clay loam, in May; stands of 80 to 100 per cent resulted from Nos. 19183, 32906, and 32907, the others representing stands of but 10 to 50 per cent.

Four varieties, said to be rich in oil content, were received from an eastern paint and oil company for trial by this station. Samples of these will be analyzed and the oil content determined. The rest of the seed is to be planted as soon as suitable conditions are at hand. Seed of the prospective crop will be analyzed for oil content, in comparison with the original seed.

MISCELLANEOUS LEGUMINOUS PLANTS.

No. 690, kulthi (*Dolichos biflorus*): Received from Bureau of Plant Industry, No. 32657. Small annual suberect vine, grows one-half to 1 foot tall, spreads equally as much, matures in four months, yields at rate of 3½ tons green manure and 1,400 pounds of seed per acre; not recommended when cowpeas are available.

Dolichos lablab: Perennial plant of early introduction to Hawaii. Vine of wild twining habit, growth coarse; flowers in four to five months; flowers reddish white, pods 2 to 4 inches long, seeds black, minutely speckled with red, hilum extended, white. This legume is valuable where a long time intervenes between plantings, and is among those recommended by the Hawaiian Sugar Planters' Station for a cover and green manure crop.

SOY BEAN, OTOOTAN, VALUABLE FOR FORAGE AND GREEN MANURING.

No. 727, asparagus bean (*Vigna sesquipedalis*): Received from Hawaiian Sugar Planters' Station under name of sasagi; compact trailing vines, spreading 4 to 6 feet, leaves similar to cowpeas, flowers purple, pods three-fourths to 1¼ feet; first pods mature in 90 days, seeds red, reniform, iris small, black with buff eye. Acre yield not obtained; good cover and green manure crop.

No. 641, Cuban peanut (*Arachis hypogæa*): Seed received by this station from G. P. Wilder, of Honolulu. Plant of trailing habit, with thick stems, requiring mounding or covering with soil at intervals. The pods are long and slender, 2¼ inches long, with very thin shuck. The nuts completely fill cavities, two to three, sometimes four in a pod, although often one end is a pop. Plant very tolerant of rains and drought, prefers light, mellow soil. While the tops are valuable as either hay or fodder, or as green manure, when turned under, the nuts can be disposed of as a money crop.

No. 637, Sesbania: Received from the College of Hawaii, under the name "Sowachen," a tall shrub, 8 to 10 feet high, spreading 4 feet upon a side; central stems and branches fibrous; leaves bipinnate; leaflets 16 to 22; pods ⅛ by 8 inches, beaked with persistent style. Valuable as a green manure crop if turned under when 3 or 4 feet high.

No. 800, Sesbania ("Densei"): Received from Kyoshito, Formosa, under the name *S. ægyptiaca*. While the leaves of *S. ægyptiaca* are described by botanists as 3 to 6 inches long, leaflets 21 to 40, the above "Densei" has leaves 9 to 15 inches and leaflets numbering 44 to 64. Since it was planted late in April, the test has not been carried far enough to ascertain whether or not it will succeed in Hawaii as a green manure crop.

Canada field or stock peas tested out by the station during the past year were a complete failure, owing to severe attack from leaf miners.

Tests with white navy beans gave fairly good results; the vines made a low compact growth, hardly gaining a height of more than 12 or 15 inches; very tolerant of dry conditions, yielding over 26 bushels of seed per acre.

Horse beans, like the stock peas, failed in making successful growth.

While tests with the dwarf Lima bean were not entire failures, the growth they put forth was insufficient to warrant further trial as a cover or green manure crop; however, the plants have very prolific bearing qualities, when conditions favor, bearing continuously for a period of two to three months if the green pods are picked. These can be disposed of as a money crop, selling at 5 cents a pound. While climbing varieties of Lima beans do well under certain conditions, one variety planted among other legumes failed to make successful growth and was discarded.

Mungo bean (*Phaseolus* spp.): Of two varieties of mungo beans tested, one gave good results. No. 582, the Mauritius mungo bean, has vines of semierect habit, 1½ to 2 feet high, spreading 1 foot upon a side. Seventy-five running feet of row yielded 104 pounds green matter, and, when thrashed, yielded 7 pounds of seed. Seeds yellow; should be planted in rows 1½ feet apart for good cover and green manure crop.

No. 634, mungo bean, "Rikutan" variety, with green seeds, low compact growth, matures in same time as No. 583, but yields much less.

REPORT OF THE SUPERINTENDENT OF THE HAWAII SUBSTATIONS.

By F. A. Clowes.

HILO SUBSTATION.

At the end of the last fiscal year the Hilo substation, which had been operated as a cooperative station, was taken over entirely by the experiment station. On account of pressing need for the available funds in other places all the experimental work was discontinued except the banana experiment.

This experiment was planned to study the influence of planting bananas at various distances apart. The varieties used were Bluefields, the banana of commerce, and the Hamakua, a variety resembling the Bluefields, although quite distinct from it. The distinguishing characteristics of the fruits of these varieties do not appear to be clearly recorded. In the last annual report of this station mention was made of some of the distinguishing characters of the plants of the two varieties. In harvesting the fruit of the plants in this experiment it was found that the Hamakua variety is almost entirely devoid of the angular shape so characteristic of the Bluefields. The Hamakua is in shape very similar to the Chinese or Cavendish banana. In ripening also the skin of the Hamakua browns in small spots like the speckling of the Chinese, whereas the Bluefields tends to brown in large patches. The flavor of the Hamakua is mild and sweet, while that of the Bluefields is sharper and more acid. So far as could be observed, there is no difference in shipping qualities of the two varieties. When very ripe the fingers of both varieties fall from the bunch, but not to such an extent as to interfere with either variety being shipped to the mainland market if harvested green and shipped properly. These observations are of value in view of the importance that these two varieties would probably assume in the event of a considerable development of the banana export business in Hawaii.

The average time from planting to harvesting of the first crop of all bunches in this experiment was one year and three and a half months. As soon as the bunches were brought in from the field they were hung in a room 6 by 10 feet, with wire screens at the ceiling, but nevertheless poorly ventilated and very warm during the heat of the day. The average length of time from harvesting to ripening was 14 days.

The following table presents the data of the yields of this first crop. In dividing the bunches into two classes, those weighing over 50 pounds and those weighing under 50 pounds, the idea is to indicate those salable for export and those which would not be acceptable for sale in mainland markets. These figures are not presented as conclusive, and it is possible that the second crop will alter the standing of the various plats of the experiment.

Yield of bananas planted at various distances.

Distance of planting.	Number of bunches per acre over 50 pounds.	Average weight of bunches over 50 pounds.	Total weight of bunches over 50 pounds.	Total weight of bunches under 50 pounds.	Gross weight of bananas per acre.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
8 by 8 feet	242	57	13,867	17,073	30,940
10 by 10 feet	218	59	12,850	8,593	21,443
12 by 12 feet	202	60	12,167	4,486	16,653
15 by 15 feet	137	64	8,783	2,658	11,441

GLENWOOD SUBSTATION.

So many factors combine to influence the growth of crops that in studying the best month of the twelve for planting any given crop only by repeating experiments over a number of years can approximately reliable conclusions be arrived at. This much has been observed, however, as affecting crops in general: With cutworm and similar pests there are certain seasons when they do more harm than at others. While opportunity has not presented itself for thorough entomological studies, it has been noticed that the most severe cutworm damage takes place during the months from December to March, inclusive. After March the greater number of the species seem to be in the pupal stage, and during the months of adult life comparatively little harm is done. It is very apparent, therefore, that for crops like corn, which are so susceptible to injury by cutworms, the safest months for planting are from March or April on till even as late as September. Oats, barley, and similar broadcasted crops seem to be better adapted to the later months, when crops carrying relatively few plants to the acre would be ruined before attaining such a stage as to be free from cutworm injury.

In September the creamery plant mentioned in the last report started operations. Many problems presented themselves in establishing a creamery in this region. The dairymen were greatly scattered, although most of them lived very close to the Hilo Railroad, and their cream was thus cheaply transported to the creamery. Comparatively few lived close enough to the creamery to deliver whole milk. Some who wished to ally themselves with the creamery lived 5 miles from the railroad. Some also who could not deliver whole milk had no separators and had so few cows and were so financially embarassed that the purchase of separators seemed too great a burden. At the end of nine months' operation of the creamery by the experiment station 15 patrons had been secured, who organized themselves into a cooperative association to operate the creamery and took over the creamery plant on June 1. Some of these patrons deliver milk, some deliver separator cream daily, some separator cream on alternate days, some gravity cream on alternate days, and one man living at a great distance, but where he can secure ice readily, delivers semiweekly.

After several months of testing the acidity of the cream delivered, using Farrington's alkaline test, 0.5 per cent of acidity seemed to be the degree of acidity which would be possible of attainment as a standard for first-grade cream. In caring for milk and cream in Hawaii at

elevations below 3,000 feet water for cooling purposes is not generally procurable which is cooler than 68° F. The care of cream from delivery at the creamery is therefore a matter requiring considerable attention. In one case home pasteurizing has enabled the patron to deliver cream semiweekly that tested less than 0.5 per cent acidity. As a result of the diffusion of information on the subject of care of cream, the supply has so far improved that a higher standard than the one adopted is possible and will be used.

In making butter from this sour cream difficulty has been experienced in securing good flavor and keeping quality. The practice has been adopted of churning at between 0.5 and 0.6 per cent of acidity, producing a mild-flavored butter, and as it is all sold to the home market for immediate consumption it does not absolutely demand the keeping quality that storage or export butter requires. With the increase in the number of patrons, cream routes can be established and more frequent delivery of cream secured. As those unfamiliar with the best dairy practice adopt more approved methods, further improvement in the supply will be obtained.

A good price is being secured for all the buttermilk produced at the creamery and the demand for cream is increasing. Cooperative buying of feeds is also being done, wholesale prices being secured to patrons.

While the actual cost of manufacture of the butter is very high, the benefits of the enterprise are great. So far the net returns to the patrons have exceeded what they were able to secure by individual effort. They are also sure of producing a grade of butter at the creamery which is sure of a market. The individual struggle to secure a market for an individual brand of butter is done away with and a feeling of security is widespread. On this account there is a growing interest in the dairy industry and there is great promise for its future development.

The Hilo market was very poorly supplied with flowers, although there was a good demand for choice flowers at times. The soil and climate of the country surrounding the substation are well adapted to growing many choice kinds of cut flowers, such as roses, Easter lilies, calla lilies, Shasta daisies, and violets. A few homesteaders were growing flowers for home ornament and in one case for sale. For eight months the substation has acted as the collecting agent for the flowers of these people, consigning them on certain days of the week to a Hilo firm for sale on commission. The sales have increased steadily, and there is now an established business that is a great help to the homesteaders in stimulating the growing of flowers as home beautifiers.

As a result of three separate trials of various standard varieties of corn, both native and varieties commonly grown in the United States, a variety grown on the Parker ranch at Waimea, Hawaii, has demonstrated itself to be the most productive of both ears and fodder of all the varieties tried. While further variety tests will be carried on, this variety has been chosen for the main crop and an effort will be made to select and save seed of it for improvement and further adaptation to local conditions. Three acres of the variety are being planted for silage.

Early Orange sorghum has been chosen as the result of one trial of 10 varieties for the main crop for the silo. It produced the highest yield of fodder and a good crop of seed.

Among the 20 varieties of grasses tried the most promising are Para grass, Italian rye, Natal redtop, *Paspalum dilatatum*, and rescue grass.

A measured plat of Para grass has yielded in five cuttings during 372 days, from June 27, 1912, to July 4, 1913, 70.7 tons of green fodder per acre. Each time the plat was cut it was top dressed with the quantity of manure produced by the animals to which the grass was fed. Para grass is a profitable crop in this region if treated in this way. Italian rye grass grows well from seed, and is a promising grass for pasture and even for soiling purposes. *Paspalum dilatatum*, commonly known locally as water grass or Australian grass, also promises to be a valuable grass for soiling purposes, and possibly for pasture. Natal redtop (*Tricholæna rosea*) also promises well as a soiling crop. Rescue grass would be a help in pasture mixtures.

Large yields of green feed have been secured from oats sown in the months from September to December. Oats sown in January were completely ruined by rust. This crop has given such promise that it is worthy of extended trial. It is not known whether the occasional failures of this crop are preventable by attention to season, variety, or fertility. While barley was in no case the equal of oats in yield, it has escaped injury from rust.

Of the legumes, soy beans and jack beans are the only ones that seem at all promising. None of the clovers has so far made satisfactory growth, although individual plants of several clovers have grown very well.

An organization of professional and amateur poultry keepers was effected through the instrumentality of the substation. This organization deals with matters of mutual interest to the members, such as marketing, purchase of supplies, holding of educational meetings, and an annual poultry show. The association has adopted the name of the Hawaii Poultry Keepers' Association.

During the year the substation has rendered executive assistance to the Hawaii Buttermakers' Association, an organization of dairymen, working along the lines of farmers' institute work.

In January four Guernsey cattle were imported for the substation. A bull, Raymond of Alta Vista 16095; sire, Raymond of Freehold V; dam, Countess Gocotte XIII. The females were heifers, as follows: Kitchener's Vimera 37887; sire, Lord Kitchener, imported; dam, Buttercup of Vimera, imported. Duchin of Upper Freehold 38466; sire, Spots Sun of Upperfreehold; dam, Duchess of Upperfreehold. Hopeful of Upper Freehold 38468; sire Spots Son of Upper Freehold; dam, Hope of Upper Freehold. The bull is standing for service, and is much in demand by the neighboring dairymen.

During the year, by means of demonstrations at the local government school, interest has been aroused in apiculture. As a result, the homesteaders are establishing home apiaries with wild bees from the surrounding forest. A small apiary has been started at the substation.

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